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HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SPACE SCIENCE AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

FIRST SESSION

FEBRUARY 6, 19, 20, 21, 26, 28; MARCH 5, 6, 7, 26, 1985

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*Ranking Republican Member.

**Serving on Committee on the Budget for 99th Congress.

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1986 NASA AUTHORIZATION

WEDNESDAY, FEBRUARY 6, 1985

House of Representatives,
Committee on Science and Technology,
Washington, DC.

The committee met, pursuant to call, at 9:30 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the committee) presiding.

The Chairman. The committee will be in order.

I want to welcome Hon. James Beggs. Jim, I must congratulate you on your budget request and am pleased that the request represents continuation of the commitment for 1 percent real growth.

I believe the committee and our colleagues in the House will continue to support the space station effort. Both the committee and the House have always supported the space program in a bipartisan manner.

I would commend the administration not only for the space station initiative, but also for the commitment to gain both private sector and international participation. A very real opportunity exists to gain increased economic benefits from our space research and development investments through financial participation by the private sector.

Furthermore, the Space Station Program offers an opportunity for international cooperation in a peaceful endeavor. I continue to believe that international cooperation is a very important aspect of the space station initiative.

I continue to be concerned about the lack of long-range plans for maintaining an orbiter production capability. The administration is speaking with many voices on future plans for space transportation activities.

There are many actions that are being taken that do not appear to support the President's stated policy of the space transportation system being the Nation's primary launch vehicle. The current controversy over the shuttle pricing policy and its relationship to United States ELV's is helping no one but our foreign competition.

I am also concerned about the lack of any new initiatives in the space science and applications area. We must assure that the shuttle and space station do not detract from a healthy science and applications program. Again, Jim, I want to congratulate you on your budget and look forward to working with you in getting the budget passed by Congress.

At this time, I am very happy to yield to the ranking minority member of Mr. Lujan.

Mr. Lujan. Thank you, Mr. Chairman.

Welcome to the committee, Mr. Beggs, once again. We got a pretty good budget, and we congratulate you for it. As he well knows, I am a strong supporter of our space program, and I am proud of this country's leadership in space.

I am also a strong supporter of the space station. I have been so from the beginning because I believe the development and utilization of a space station is this country's next, logical step in the development and leadership in space technology.

I support the space station for many of the same reasons that I supported development of the shuttle, because it is the proper vehicle for encouraging the increasing involvement of private enterprise in space, and because it provides increased capabilities for space scientists.

Private industry realizes that the space program is responsible for not only the development of new technology, but also for the development of many new industries; from the development of new, space-related communications industry to the rapid advancement in the computer industry.

The space scientists are responsible for the basic research, that we can be certain will spawn increased understanding of our earth and our universe, and will result in practical applications in a wide variety of areas. The space scientists are also responsible for the explanation of our solar system and space.

Mr. Chairman, I would hope that these hearings will be a forum for keeping our space program in the proper direction, a direction that sees the Federal Government providing the research, development, and leadership as well as the encouragement and inducement for increased private investment.

I trust my fellow members of the committee share my enthusiasm and support for our space program and the space station, as a matter of fact, I know they do. We didn't have enough spots on the committee to meet the needs of all of the members, and I must think we will have the support of the space program and space station.

Those who are hesitant in their support should take a second look at this station and at the benefits to our technology. As I have said before, the space station is the next logical step in maintaining our leadership in space.

America has the leadership in space because the Federal Government has invested the time, money, and talent to put us there. We will maintain that leadership if private enterprise makes the same investment to keep us there.

[The prepared opening statement of Mr. Walker follows:]

OPENING REMARKS

REPRESENTATIVE ROBERT S. WALKER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

POSTURE HEARING

FEBRUARY 5, 1985

GOOD MORNING. MR. BEGGS, LET ME JOIN IN WELCOMING YOU HERE BEFORE THE COMMITTEE FOR OUR ANNUAL POSTURE HEARING. AS ALWAYS, IT WILL BE A PLEASURE TO HEAR YOUR VIEWS ON THE PRESIDENT'S PROPOSED BUDGET FOR FISCAL YEAR 1986.

I AM VERY ENTHUSIASTIC ABOUT THE OPPORTUNITY WHICH FACES THE UNITED STATES TODAY. A QUARTER OF A CENTURY AFTER PRESIDENT JOHN F. KENNEDY CHALLANGED THE NATION TO ACHIEVE THE GOAL OF PLACING AN AMERICAN ON THE SURFACE OF THE MOON AND RETURNING HIM SAFELY TO EARTH, WE HAVE A SPACE PROGRAM WHICH SHOULD BE THE PRIDE OF EVERY CITIZEN OF THIS GREAT NATION.

WE HAVE DEVELOPED THE SPACE SHUTTLE WHICH HAS MADE SPACE FLIGHT A

REGULAR OCCURANCE. WE ARE ON THE BRINK OF DEVELOPING MAJOR NEW COMMERCIAL UNDERTAKINGS WHICH COULD RAPIDLY LEAD TO A SPACE-BASED ECONOMY FAR BEYOND OUR WILDEST DREAMS.

ONLY FIFTY YEARS AGO, THE UNITED STATES WAS RECOVERING FROM THE GREAT DEPRESSION. THE ARMY AIR CORPS WAS FLYING BIWING FIGHTER AIRCRAFT. DR. GODDARD WAS LARGELY IGNORED IN THIS COUNTRY. THE AIRLINE INDUSTRY WAS STILL IN ITS INFANCY, AND COMPUTERS WERE YET TO BE DEVELOPED.

THE SPACE PROGRAM HAS BEEN ONE OF THE GREATEST TECHNOLOGY MOVERS EVER UNDERTAKEN. DURING OUR LIFETIMES WE HAVE SEEN A PERIOD OF TECHNOLOGICAL GROWTH WHICH HAS BEEN UNEQUALED IN HISTORY. MANY OF US HAVE GRANDPARENTS WHO RECALL THAT WINTER DAY WHEN THE WRIGHT BROTHERS TOOK MAN'S FIRST FALTERING STEPS TO FREE HIMSELF FROM THE BOUNDS OF THE EARTH. SOON WE WILL SEE THE DAY WHEN WE WILL ACCEPT MANNED SPACE FLIGHT THE WAY WE VIEW COMMERCIAL AIRLINES TODAY.

THERE ARE STUDIES AVAILABLE THAT INDICATE THAT WITH THE FULL COMMERCIALIZATION OF SPACE WE CAN DEVELOP A ONE TRILLION DOLLAR A YEAR SPACE ECONOMY BY THE YEAR 2010, AND THAT WILL GROW TO A FOUR-AND-A-HALF TRILLION DOLLAR A YEAR SPACE ECONOMY BY THE YEAR 2050.

OUR NEXT MAJOR STEP INTO SPACE WILL BE THE DEVELOPMENT OF THE FIRST PERMANENTLY MANNED SPACE STATION. THIS PROGRAM IS ONE WHICH HAS EXCITED THE PUBLIC AND THE CONGRESS. WE ARE PLEASED TO SEE THAT THIS BUDGET CONTAINS A MAJOR FINANCIAL COMMITMENT IN THIS AREA. I MUST SAY

THAT I WAS SOMEWHAT CONCERNED TO LEARN THAT THE BUDGET REQUEST WHICH WENT TO OMB WAS CUT BY FIFTY MILLION DOLLARS FOR THE SPACE STATION.

HOWEVER, YESTERDAY, DR. KEYWORTH, THE PRESIDENT'S SCIENCE ADVISOR INFORMED THE COMMITTEE THAT THIS REDUCTION WILL ONLY SLOW THE PROGRAM BY SIX MONTHS. IF THAT IS ACTUALLY THE CASE I BELIEVE THAT IN THESE TIMES OF SOARING DEFICITS AND TOUGH ECONOMIC CHOICES WE CAN UNDERSTAND THE PROPOSAL.

WHAT CONCERNS MANY MEMBERS OF THE CONGRESS IS THE POTENTIAL THAT WE MIGHT SEE A REPLAY OF THAT PERIOD DURING SHUTTLE DEVELOPMENT WHEN MORE AND MORE WAS DIVERTED FROM OTHER NASA PROGRAMS TO SUPPORT SHUTTLE AND THE RESULT WAS THAT OTHER PROGRAMS LOST CRITICAL MASS.

THE SPACE STATION IS A BOLD STEP INTO THE FUTURE. IT IS A PROGRAM WHICH AMERICA NEEDS TO SEE CARRIED THROUGH TO SUCCESS. WE HOPE THAT WITH THE COMMITMENT OF THIS ADMINISTRATION, AND THE SUPPORT OF THE CONGRESS, THAT WE WILL SEE THE PROGRAM MOVE FORWARD RAPIDLY.

THANK YOU, MR. CHAIRMAN.

The **Chairman**. Let me ask the new chairman of the Space Science Applications Subcommittee, Mr. Nelson, if he has any comments.

Mr. **Nelson**. I don't, Mr. Chairman.

The **Chairman**. Mr. Lewis.

Mr. **Lewis**. Thank you, Mr. Chairman.

I also want to welcome you here today, Mr. Beggs, and I look forward to hearing your testimony on the NASA budget for fiscal year 1986.

I can certainly appreciate the challenges that face NASA today. The budget deficits cannot be ignored, and I recognize we must accept some sacrifices. However, when our competitors are increasing their support for research and technology, it would indeed be shortsighted to view research as a luxury that can be put aside until better days.

I was happy to see the modest increase of NASA's funding for aeronautical programs and especially pleased that the Advanced Turboprop Program will be adequately funded this year, and 87 flight tests will be assured.

Fuel savings of 20 percent, timely development of this technology could significantly impact our balance of trade. Aeronautics is one of the few areas where we still enjoy a positive trade balance today.

This is being seriously challenged. I am sorry the Advanced Composite Structures Program did not fare as well. This, too, is a technology which could have significant impact on our ability to compete in an international market, and I sincerely hope this technology will continue to be pursued by the private sector.

Looking further ahead, Mr. Beggs, I am interested in hearing what NASA's plans are for pursuing higher speed aeronautics. Specifically, I would be interested in hearing you address what the future holds for hypersonic research, when can we look forward to transatmospheric flight?

This committee is concerned that progress in high-speed aeronautics has not been as rapid as many of us would wish. I look forward to hearing your views on these and other issues. Thank you, Mr. Chairman.

The **Chairman**. Thank you very much, Mr. Lewis.

Mr. Beggs, we are pleased to have you.

STATEMENT OF JAMES M. BEGGS, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, DC, ACCOMPANIED BY C. THOMAS NEWMAN, COMPTROLLER

Mr. **Beggs**. Thank you, Mr. Chairman, very much. I take cognizance of the questions addressed.

Mr. Chairman and distinguished members of the committee, it is a pleasure for me to appear before this committee to present President Reagan's budget request for NASA for fiscal year 1986. The total agency request is $7.9 billion, of which $2.9 billion is for research and development, including $354 million for aeronautical research and technology; $3.5 billion for space flight, control and data communications; $149 million for construction of facilities; and $1.3 billion for research and program management.

The NASA budget for fiscal year 1986 provides for solid progress toward the aeronautics and space objectives approved by the administration and the Congress. Consistent with last year's congressional endorsement of the President's space station initiative, our planning in fiscal year 1986 will proceed but at a slightly slower pace than we had anticipated last year.

Our planning efforts will focus upon space station system definition and technology development and will incorporate examination of both a man-tended approach and advanced automation and robotics technologies. We hope to conclude agreements with ESA, Canada, and Japan in the near future to allow for parallel definition effort, beginning April 1, leading to significant international participation during the development phase.

As an aside here, Mr. Chairman, we were very pleased with the recent conclusion of the Summit Council meeting in Rome where they endorsed the participation of ESA in the phase B work.

With the space shuttle an increasingly mature system, a permanently manned space station is the next logical step in space for this Nation to take. We look forward to beginning its detailed design and development in 1987 directed toward building this station within a decade.

The space transportation system, built around the space shuttle, will continue to gain operational maturity and demonstrate new capabilities. In fiscal year 1986, we plan 14 launches carrying commercial payloads, national security missions and NASA missions to Earth orbit and to the planets. The Centaur upper stage will be launched from the shuttle for the first time, the first shuttle flight will be launched from Vandenberg Air Force Base and we will begin development of an orbital maneuvering vehicle to provide a new capability for on-orbit operations.

Space science and applications will experience a banner year. Early in 1986, a special set of three telescopes known as the ASTRO payload will fly aboard the shuttle to make observations of Halley's Comet. In early 1986, the Voyager spacecraft will encounter the planet Uranus to give us the first closeup look at that large, unusual, and unexplored planet and then continue on its way to Neptune.

The Galileo mission will be launched in late spring of 1986. An option has been added to allow the Galileo spacecraft, while en route to Jupiter, to fly by and observe the asteroid Amphitrite. The Galileo orbiter/probe will encounter Jupiter in December 1988 where the probe will be released into the dense atmosphere of that planet while the orbiter spacecraft remains in orbit to obtain additional data on the planet and to take a close look at its satellites. During the same planetary launch window, the Ulysses spacecraft, formerly known as the international solar polar mission, will be launched toward Jupiter and will use the tremendous gravitational force of that planet to accelerate into a trajectory that will permit inspection of the sun at high latitudes never before available for observation.

Later in 1986, the Hubble space telescope will be launched into Earth orbit to provide resolution far superior to that available in even the best ground-based telescopes and to provide a quantum jump in our ability to observe and understand the universe. In addition, we will continue working aggressively on future missions including the Gamma Ray Observatory, the Venus radar mapper mission, the Mars observer, and the upper atmospheric research satellite.

Consistent with the congressional action on the fiscal year 1985 budget, we will be pursuing development of the advanced communications technology satellite planned for launch in 1989 to demonstrate the technology needed for the United States to remain competitive in this important area.

Although fiscal year 1986 will be a vigorous year for the Space Science and Applications Program, it has been necessary to defer initiation of new projects, which, of course, will be essential to the future vitality in the space science and applications area. I believe the hiatus in fiscal year 1986 is reasonable provided we make appropriate provision for new initiatives in future years.

In late 1984, NASA established the Office of Commercial Programs pursuant to the administration's national commercial space policy. This office will provide a focus to encourage commercial use of space. The fiscal year 1986 budget will continue and expand initiatives which began in fiscal year 1985 to stimulate research and development by aerospace and nonaerospace companies, facilitate access by private and academic entities to NASA facilities and equipment, establish new links with the private sector, and establish centers to promote the commercial development of space.

In aeronautics, the fiscal year 1986 budget focuses on research and technology activities which supply and replenish the reservoir of technology which has been the fundamental source of our Nation's preeminence in aviation.

In addition to the more general and generic technology, the budget continues a carefully selected group of systems technology efforts including the numerical aerodynamic simulation project designed to move the United States to the forefront in the extremely complex area of computational fluid dynamics. We will also be working on the advanced turboprop propulsion systems to provide technology for a new generation of fuel-efficient transport aircraft.

The budget provides for a modest growth in the space research and technology activities which are also crucial to the future U.S. leadership in space. It also provides for establishment of the fully operational three-spacecraft TDRS system.

Mr. Chairman, I am satisfied that the budget we are requesting for fiscal year 1986 is a reasonable budget considering the constrained fiscal environment in which all programs must be considered, and I am satisfied that we can and will achieve substantial progress toward all of the Nation's major objectives for which NASA is responsible.

That concludes my statement, Mr. Chairman. I would be pleased to respond to questions.

[The prepared statement plus answers to questions asked of Mr. Beggs follow:]

February 6, 1985

Statement of

James M. Beggs
Administrator

National Aeronautics and Space Administration

before the

Committee on Science and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Committee:

It is a pleasure for me to appear before this Committee to present President Reagan's budget request for NASA for FY 1986. The total Agency request is $7.9 billion, of which $2.9 billion is for Research and Development, $3.5 billion for Space Flight, Control and Data Communications; $149 million for Construction of Facilities; and $1.3 billion for Research and Program Management. The NASA budget for FY 1986 provides for solid progress toward the Aeronautics and Space objectives approved by the Administration and the Congress.

SPACE STATION

In response to President Reagan's directive of last year to develop within a decade a permanently manned Space Station, NASA has begun a major new endeavor, one that I believe will ensure United States leadership in space during the decade of the 1990's and beyond, while at the same time providing a sound framework for a mutually beneficial cooperative program with our friends and allies abroad. Progress, so far, has been substantial.

We have initiated a competition within U.S. industry for Space Station definition and preliminary design that is scheduled to commence in April of this year and lead to a thorough understanding of Space Station systems prior to hardware development. We have begun a technology development program that will enable us to incorporate the proper level of advanced, sophisticated systems aboard the Station. In accordance with the President's directive, and as a follow-up to the results of the London Economic Summit at which the attending nations welcomed the U.S. invitation to participate in the Space Station development, we have held extensive discussions with representatives of the European Space Agency, Canada, and Japan. These discussions should lead initially to their own Space Station definition studies, in parallel with ours, and ultimately to a partnership in Space Station hardware development and use. We have established a Space Station management structure that designates the Johnson Space Center in Houston as "Lead Center" while fully utilizing the talents of other NASA installations. We have also established a strong user or customer focus to the Space Station Program, reflected organizationally in our creating Space Station Chief Scientist positions at both NASA Headquarters and the Johnson Space Center. It is reflected too in the utilization of a specially constituted Space Station Science Advisory Committee chaired by Dr. Peter Banks of Stanford University and by the emphasis we've placed upon Space Station mission requirements. Advocacy groups have been established to represent customer requirements for potential commercial, scientific, and technology development payloads and these will be incorporated in the definition and preliminary design studies that begin in the spring.

As we've undertaken these activities, we have been mindful of the directives received from Congress last year when it approved the Agency's budget request of $150 million to begin the Space Station Program. The study of a "man-tended" approach, requested by Congress, has been set in motion by its incorporation in the definition and preliminary design activity; U.S. industry will examine this option in conjunction with the main body of analysis. The Advanced Technology Advisory Committee has been established to analyze, and report to the Congress upon the potential for advancing the technologies of automation and robotics. This analysis will be utilized by U.S. industry as it conducts the Space Station definition studies. Reports on Space Station management and platform selection criteria have also been prepared and submitted in response to requests from this Committee.

The Station will consist of a manned base with accompanying unmanned platforms, one of which is likely to be in polar orbit. The base and platforms would be carried aloft in modular sections by the Space Shuttle which would assist in the on-orbit assembly and check-out of the Space Station. The Shuttle would also be used for logistics resupply and crew rotation. By utilizing both manned and unmanned elements, the Space Station will enjoy the substantial advantages offered by both modes of space flight. Combined with the unique advantages provided by a truly permanent presence, the Station will significantly enhance United States capabilities in space.

In FY 1986 NASA is requesting $230 million for Space Station activities. During the fiscal year the Space Station definition and preliminary analysis will be under way. The advanced technology development activity will be in progress while user payload requirements will be refined and updated. In addition, a highly innovative Technical Management and Information System will be established to enhance overall program management and a

Space Station operations concept will be developed. Our current schedule envisions that Space Station hardware development will begin in 1987. This schedule allows for international partners in the Space Station Program to work in step with NASA. As importantly, it enables NASA to work toward the objective of having a Space Station within a decade. From that time forward, I believe there will always be Americans living and working in space.

SPACE SHUTTLE

The President has directed that NASA's first priority is to make the STS fully operational and cost effective in providing routine access to space. He has also directed that the STS program will receive sustained commitments by all affected departments and agencies and directed that enhancements of STS operational capability, upper stages and efficient methods of deploying and retrieving payloads will be pursued as national requirements are defined.

While I am extremely proud of our record of 15 highly successful launches, I recognize that it is essential that we continue to move forward to drive down Shuttle costs and provide the opportunities for further commercialization of space so that this country can compete effectively in the international arena and maintain its leadership in space. I am concerned that we might find ourselves in the same situation in the space industry that we now find ourselves in the automobile industry. We cannot look at space launches without also looking at the long term impact on the satellite manufacturers, the upper stage industry and the other infrastructure we have built up in this country over the last 26 years. With aerospace and agriculture contributing effectively to helping alleviate our balance of payments problem it is essential that we take additional steps to ensure that these jobs are not lost to the U.S. economy.

The STS capability includes a highly competent, experienced STS team; the four Orbiter fleet - Columbia, Challenger, Discovery, and Atlantis; commercial and government upper stages, two Launch Pads at the Kennedy Space Center; the Vandenberg Launch Site; production capabilities and facilities to support 24 flights per year; and the dedication and experience to provide customers easy access to space.

At the present time two of our Orbiters, OV-099 Challenger and OV-103 Discovery, are operational, OV-102 Columbia is undergoing modifications and OV-104 Atlantis has a planned April 1985 delivery.

While the Shuttle team has an unblemished safety record, we must ensure that each mission is safe and reliable. Our planning during the next few years focuses on bringing the STS to operational maturity. This includes: essential modifications to the Orbiter fleet, improved life and operating margins on the main engines, particularly the high pressure pumps, and ensuring that an improved operational capability is in place. It is also essential that we provide increasingly efficient and customer friendly operations for Shuttle and Spacelab users. We are working with DOD to prepare for manned space operations at Vandenberg Air Force Base and the Shuttle Operations and Planning Center at Colorado Springs.

This year saw the first full year of operations at Kennedy Space Center (KSC) under the Shuttle Processing Contract and the Base Operations Contract. Both contracts continue to show increased efficiencies. At the Johnson Space Center we are planning a Space Transportation System Operation Contract to consolidate work now being performed by 16 contractors into a single contract.

Two of the highlights in the Space Program this past year which hold great hope for the future are the retrieval and repair of the Solar Maximum Mission satellite and the retrieval of the Westar and Palapa communication satellites. The Solar Max spacecraft had been launched in 1980 but was disabled by the failure of its fine-pointing system. The Solar Max repair mission enabled the satellite to resume its program of solar observations and measurements. The Westar and Palapa satellites were spectacularly retrieved on our November mission and brought back to Earth. They are currently being refurbished and we understand that the space insurance industry is in the process of reaching an agreement on their resale.

In FY 1985 we plan 10 Shuttle flights including two dedicated DOD missions, two Spacelab missions, the deployment of 15 communication satellites, and the second TDRSS launch using the IUS, the third TDRSS will be launched later in 1985. 1985 will also see the completion of the upgrading of Columbia and the inaugural flight of the fourth Orbiter, Atlantis.

Our FY 1986 budget request for the Space Transportation System Program is $3160.9 billion. This supports 14 missions, or an average of one approximately every 25-30 days, with the scheduling dominated by the planetary launch window in May. Pad B at KSC will be brought into service in time to support the Galileo Jupiter launch, only six days after the Ulysses (International Solar Polar Mission) is launched from Pad A. The missions include four Spacelab flights, launch of the Hubble Space Telescope, numerous communications satellites, two flights of the McDonnell Douglas pharmaceutical pilot production module, the first flight from Vandenberg AFB, one other dedicated DOD mission, two payloads to make observations of Halley's Comet, and several materials processing payloads.

With the flight rate increasing and the Orbiter production program winding down, there is continued emphasis on Orbiter spares and the Space Shuttle Main Engine. The initial increment of structural spares has been defined, negotiated and production is underway with deliveries scheduled thru 1987. This provides a set of major structural components to be used in the event of major damage to an Orbiter, while helping to maintain a production base, and potentially reducing the lead time to build an additional Orbiter, if one should be required in the future. Since last year, there has been a major re-planning of the Space Shuttle Main Engine (SSME) Program, with a focus on limiting the scope of improvements to increase operating life and design margins of the current configuration. In addition, we are establishing an advanced development effort having two major thrusts; alternative engine contractors and a technology test bed.

Major efforts in the launch and landing area include activation and readiness of launch pad B, activation of the third Mobile Launch Platform and modifications to provide the capability to service the Centaur upper stage for the initial Centaur flights. Construction of the new Solid Rocket Booster (SRB) refurbishment and assembly facility at KSC will be completed. The fabrication of filament wound case (FWC) segments will continue and the development testing will be completed.

The Orbital Manuevering Vehicle (OMV), a reusable, remotely piloted system which represents a significant extension of capability for the Space Transportation System will be initiated in 1986 and be available for flight use in 1990.

SPACE SCIENCE AND APPLICATIONS

The Space Science and Applications program has had impressive results this past year. Some which are particularly noteworthy include the completion of the IRAS mission, the restoration of the Solar Maximum Mission, the flight of the Shuttle Imaging Radar-B and the Large Format Camera, the launch of the Active Magnetospheric Particle Tracer Explorers, Earth Radiation Budget Experiment, and a host of other first-rate scientific achievements.

The budget request for Space Science and Applications of $1613.2 million will support the continuance of a healthy and scientifically challenging program. Space Science will experience a banner year in 1986 as past investments become reality. Early in the year a special set of three telescopes known as the ASTRO payload will fly aboard the Shuttle to make observations of Halley's Comet. The Voyager Spacecraft will encounter the planet Uranus in 1986, to give us the first close-in observation of that large, unusual and unexplored planet and then continue on its way to Neptune. The Galileo Mission will also be launched in late Spring of 1986. An option has recently been added to the Galileo mission to allow for the spacecraft to fly by and observe the asteroid Amphitrite while on the way to Jupiter. The Galileo orbiter/probe will encounter Jupiter in December 1988 where the probe will be sent into the dense atmosphere of that planet while the orbiter spacecraft remains in orbit to obtain additional data on the planet and to take a close look at its satellites. During the same planetary launch window, the Ulysses spacecraft, will be launched toward Jupiter and will use the tremendous gravitational force of that planet to accelerate into a trajectory that will permit inspection of the Sun at high latitudes never before available for observation.

Later in 1986, the Hubble Space Telescope will be launched into Earth orbit to provide resolution far superior to that available in even the best ground-based telescopes and thereby providing a quantum jump in our ability to observe and understand the Universe. The Space Telescope like Galileo and Ulysses involves extensive contributions from our European partners. We will continue working aggressively on other ongoing space science and applications missions including the Gamma Ray Observatory, the Cosmic Background Explorer, the Extreme Ultraviolet Explorer, the Venus Radar Mapper, the Upper Atmosphere Research Satellite, and the Mars Observer.

The Life Sciences budget will allow continuation of work to ensure astronaut health and productivity in space. It will also support the activities needed to ensure success in establishing a permanent presence in space with the Space Station.

Our Space Applications program will be supported at the $551.8 million level. Consistent with the congressional action on the FY 1985 budget, we will be pursuing development of the Advanced Communications Technology Satellite planned for launch in 1989 to demonstrate the technology needed for the United States to remain competitive in this important area.

This funding level will allow for the continued development of the Upper Atmospheric Research Satellite and the NROSS Scatterometer as well as the critical research in solid Earth and environmental observations. We will also continue ongoing development efforts in Materials Processing and Information Systems.

Although FY 1986 will be a vigorous year for the Space Science and Applications program, it has been necessary to defer initiation of new projects. I believe the hiatus in FY 1986 is reasonable provided we make appropriate provision for new initiatives in future years.

COMMERCIAL PROGRAMS/TECHNOLOGY UTILIZATION

In support of the National Commercial Space Policy and the amended National Aeronautics and Space Act of 1958, NASA in 1984 established the Office of Commercial Programs to pursue new ways of reducing the technical and financial risks of doing business in space. The Commercial Programs Office will provide a focus for a NASA-wide program to encourage U.S. private investment in commercial space ventures and facilitate commercial application and transfer of existing aeronautics and space technology.

The FY 1986 request of $30 million for Commercial Programs will continue and expand a series of initiatives begun in FY 1985 to support the National Commercial Space Policy and to implement NASA's Commercial Use of Space Policy. These initiatives will help stimulate research and development by aerospace and non-aerospace companies; increase access to NASA's facilities and equipment; establish new links with the private sector and establish centers to provide for the commercial development of space.

NASA's FY 1986 proposal of $11.1 million for Technology Utilization will allow continued effort to transfer NASA-developed technology to U.S. industry, the public and other Government agencies.

AERONAUTICAL RESEARCH AND TECHNOLOGY

NASA is requesting $354.0 million in FY 1986 for Aeronautical Research and Technology to provide the broad technology base essential to the preservation of U.S. leadership in aviation. The program includes fundamental research in the aeronautical disciplines and a carefully selected group of focused systems research directed at the interactions of disciplines and components and the evaluation of new concepts.

Key elements in FY 1986 include the Advanced Turboprop program which is developing single- and counter rotation propeller and aircraft integration technologies for a new generation of fuel efficient aircraft. Critical technology gaps are being addressed through proof-of-concept testing of the unducted fan and flight testing of a large-scale advanced propeller in FY 1987 as directed by Congress. In addition, the Numerical Aerodynamic Simulation Program will begin to provide the U.S. with the world's most advanced capability for numerical simulation of aerodynamic flows about an aircraft and through the rotating turbomachinery of engines. The initial system will be brought to operational status in FY 1986.

Flight research activities to explore the operating characteristics of the DARPA/NASA X-29 forward swept wing research aircraft will continue and the DARPA/NASA X-wing rotor research aircraft is being readied for first flight in early FY 1987. Similar activities are planned in conjunction with the Navy to develop an oblique wing research aircraft.

SPACE RESEARCH AND TECHNOLOGY

The FY 1986 Space Research and Technology request of $168.0 million provides for modest growth in a broad base of advanced technologies contributing to the Agency goals of improved operational effectiveness of the Space Transportation System; an efficient and productive Space Station; and to enable the United States to lead in the exploration of the solar system and observation of the Earth from space. It also supports expanding military and commercial space needs with technological options which make future space systems and applications a practical and economical reality.

Major programs in FY 1986 include: research on advanced components and diagnostic instrumentation to improve the life and performance of large LOX/hydrogen engines leading to tests in a SSME test-bed engine; vehicle and propulsion technologies directed at the critical needs for a reusable, space-based orbital transfer vehicle; automation research addressing teleoperations and robotics for spacecraft and Space Station applications; development of in-space experiment capabilities to provide the technology base for cryogenic fluid management, large thermal energy systems; and to investigate the dynamics and control of large, flexible structures. Experimentation in space is critical to the development and verification of future space systems and commercial applications and will be an important focus of the space R&T program. Significant events occurred in this area during 1984. The Long Duration Exposure Facility (LDEF) was deployed in April and is scheduled to be retrieved in March 1985. It will be returned to Earth so that the long-term effects of space exposure can be evaluated on selected materials and components. In August, an experimental, 100 foot solar array was deployed from the Shuttle Orbiter Discovery cargo bay. The array was instrumented to provide the first research data on the dynamic response of large, highly flexible structures.

SPACE TRACKING AND DATA SYSTEMS

For the Space Tracking and Data Systems Program, NASA is requesting a total of $824.5 million for FY 1986. These funds will provide for the continuation of the vital tracking, command, telemetry, communications, and data processing support to meet NASA flight program requirements. The transition of the ground tracking network to a space tracking capability for low Earth orbit missions is continuing. This transition began with the launch of TDRS-1 in April of 1983. Since the dramatic recovery from the upper stage failure, the TDRS-1 has successfully supported the various Shuttle missions, as well as Spacelab, Landsat, Solar Mesopheric Expolorer, Earth Radiation Budget Experiment, and the Solar Maximum Mission.

The required satellite constellation will be completed with the launches of TDRS-2 in February of this year and TDRS-3 later this year, and full operational capability of the space network will be achieved with the completion of the required checkout and testing.

The Ground Networks, composed of the residual Space Tracking and Data Network (STDN) and the Deep Space Network (DSN), will continue to provide tracking and data support to a variety of missions during FY 1986. In anticipation of the TDRSS full operational capability, we are continuing to make substantial reductions in our ground tracking network which supports near-Earth spacecraft. The STDN is now half the size it was five years ago, and most of the remaining stations will be closed or transferred to other agencies when TDRSS becomes fully operational.

The Deep Space Network, which provides the only means of communications with our deep space and interplanetary missions, is on the threshold of an especially active and critical period. The Networks Consolidation Program is scheduled to be completed by the end of February 1985 which will permit the DSN to assume support responsibility for spacecraft above the view of the TDRSS as well as for those older spacecraft which are not compatible with TDRSS. A major DSN upgrade is scheduled for completion in the Fall of 1985 which will allow us to meet the increasingly complex mission needs.

Two major activities in NASA's Communications Program will become operational in FY 1986, both of which will employ available advanced technologies developed by the communications industry--a Time Division Multiple Access system which will provide operational circuits via satellite, and a Program Support Communications Network which will handle NASA's growing non-operational communications needs among its Centers.

CONSTRUCTION OF FACILITIES

Of the FY 1986 Construction of Facilities request of $149.3 million, approximately one-third is allocated to essential repairs, rehabilitations and modifications, and minor construction, while approximately one-half is allocated to 14 major projects in support of critical programmatic requirements. The budget provides needed facilities support for Space Shuttle operations and related activities such as the construction of an Orbiter Modification and Refurbishment Facility at KSC and modifications for an Advanced Technology Engine Test Stand at MSFC.

Three major facility projects in support of Space Science activities are also included. A Micro-devices Laboratory at JPL will provide the necessary environment for conducting microelectronics research and technology development for solid state devices, spaceborne very large scale integrated circuits, and advanced computer architecture. At Goddard Space Flight Center, the budget request will permit the construction of the initial phase of a Spacecraft Systems Development and Integration Facility. This project, when completed with a similar amount in next year's budget, will provide the capability for developing and integrating spacecraft of sizes that can exploit the full capability of the Shuttle.

Facility projects in support of Aeronautics and Space Technology include the second increment of funding required to complete the Numerical Aerodynamics Simulation Facility at Ames Research Center and modification of the 16-foot Transonic Tunnel at Langley Research Center for improved productivity and research capability.

RESEARCH AND PROGRAM MANAGEMENT

The NASA institution is appropriately sized and capable of carrying-out the FY 1986 program. In the FY 1986 Research and Program Management Budget, there are, however, two significant changes from FY 1985; first, the salary rate for civil service personnel is five percent lower in FY 1986 than FY 1985. This reduction in salary rates is part of the Government-wide reduction directed by the President beginning in 1986. The other major change has been a reduction of 200 civil service FTE's and $21.0 million related to the President's drive to reduce administrative costs in the Government. We will endeavor to accomplish the reductions in a manner to minimize the impact on program accomplishment. The balance of the changes in R&PM reflect a constant level of operations at expected price levels.

Mr. Chairman, I am satisfied that the budget we are requesting for FY 1986 is a reasonable budget considering the constrained fiscal environment in which all programs must be considered and I am satisfied that we can and will achieve substantial progress toward all of the Nation's major objectives for which NASA is responsible.

Responses to Written Questions Submitted by Chairman Nelson during the February 6, 1985, hearing at which Mr. Beggs testified.

QUESTION A-1:

What steps is NASA taking to enhance awareness within government of the value of aerospace programs as an instrument of U.S. foreign policy?

a. How would you characterize NASA's current role and influence in foreign policy? Is it adequate? If not, how might it be improved?

b. What steps, if any, is NASA taking to increase awareness of aerospace programs as instruments of foreign policy?

c. It is our understanding that no agency of government in this country has given a comprehensive look into if, and to what intent, our space capabilities could be used as an effective foreign policy tool among third world nations. Why has such a study not been conducted? What can be done to change this situation.

ANSWER A-1:

a. & b. In response to the Statutory mandate that NASA conduct its activities "so as to contribute materially to...cooperation by the United States with other nations," most of NASA's programs since its inception have had some form of international involvement. While NASA has no specific budget for international cooperation, we look for international cooperation in our programs where it is mutually beneficial. NASA has also worked quite closely with the White House and the State Department over the past several years to demonstrate the value of international participation in our programs to U.S. foreign policy goals. As a result, the perception that aerospace programs are valuable as instruments of U.S. foreign policy is becoming more widely recognized. This was most recently demonstrated by the inclusion in the President's State of the Union Address last year of international participation in the Space Station as one of its primary elements in order "to strengthen peace, build prosperity, and expand freedom for all who share our goals," and a reaffirmation of this element in this year's State of the Union address. Furthermore, the State Department has two representatives on the NASA Space Station Negotiating Team.

c. We understand that State Department has conducted many studies on the use of U.S. space capabilities as an effective foreign policy tool, and therefore suggest that the question more appropriately be referred to the Department of State, Bureau of Oceans and

International, Environmental, and Scientific Affairs.

QUESTION A-2:

Past experience has demonstrated the potential for space transportation systems development and operation to seriously impact funding for other NASA programs.

a. How will you ensure that the Space Station will not encroach upon other programs?

b. How would you characterize the level of technical risk associated with the Space Station?

c. What are the key technology developments required?

ANSWER A-2:

a. We feel that the Space Station can be developed within the current projection for the NASA budget and we are committed to provide an appropriate balance between Space Station and other agency programs. Within the currently projected future year funding, NASA plans to allocate at least 20 percent of R&D and SFCDC funds for Space Science and Applications. The current definition phase for the Space Station, 1985-1987, will provide sufficient understanding of the job to be done within the stated budget guidelines.

b. This Space Station design will include the latest technologies that have been matured to a level of acceptable risk. We have strong motivation to mature advanced techniques that offer promise for desired improved capabilities and reduced operating costs.

c. Some examples of the high leverage technologies that are desirable to include in the Space Station when they mature to a level of acceptable low risk include: solar dynamic power systems, two phase thermal management systems, closed-loop Environmental Controlled Life Support System techniques, and advanced automation techniques.

QUESTION A-3:

NASA has articulated the view that Space Station development will be a international cooperative development.

a. What is the status of international negotiations?

b. What policy guidelines have been established for international participation?

c. What would be the impact of a Space Station schedule slip on the international negotiations?

ANSWER A-3:

a. NASA is currently conducting separate negotiations with ESA, Canada and Japan for three bilateral agreements covering the Phase B definition studies. All three negotiations are essentially on schedule. We expect to sign the Memorandum of Understanding in March after internal national approval is gained by each Party, so that our international partners can enter definition activities in April at the same time NASA starts its definition activities.

b. Guidelines for the Space Station Program have been based on the basic guidelines for international cooperation that we have followed successfully for over twenty-five years. These guidelines were given to our potential partners in the Space Station Program last June at the first international workshop:

1. Cooperation must be mutually beneficial to the United States and the international partners.

2. International partners should have requirements for long-term utilization of the Space Station.

3. International partners will be government agencies.

4. International partners will assume full technical and financial responsibility for developing their projects.

5. Agreements for international participation will be for specific projects or functions with obligations and responsibilities clearly defined.

6. Agreements will provide sufficient flexibility to accommodate programmatic and design changes.

7. Clean managerial and technical interfaces will, to the fullest extent practical, be maintained between the various portions of the Space Station.

8. While principal responsibility for management, integration, and operation of the Space Station will reside with the United States, international partners with substantial investments in the Space Station will also have a role in the management and operations commensurate with their investment.

9. Ownership and responsibility for sustaining engineering and operational management of internationally provided elements and functions are expected to remain with the international partner.

10. A common set of technical standards, such as safety and reliability, will be developed and applied

in common to all Space Station participants.

11. This cooperative program will be conducted to avoid the unwarranted transfer of technology among the partners while ensuring that sufficient information to achieve effective interfaces will be exchanged.

c. As was said during the hearings, while our partners are pleased to see some schedule relief during the first half of the definition activity, it is important to follow a schedule that allows the agency to continue to maintain the pressure that is needed to ensure that our partners move with diligence and speed into the program, and maintain this momentum throughout the program.

QUESTION A-4:

What is your response to the following assertions made in the OTA Space Station study?

a. There is no compelling reason to build the NASA baseline design.

b. Less costly designs and different management options should be reviewed.

c. Specific design and cost options should not be chosen until long-range civil space goals have been set.

ANSWER A-4:

a. The OTA assessment on "Civilian Space Station and the U.S. Future in Space" addresses many issues regarding not only aspects of a manned Space Station but also overall civilian national goals and objectives in space. There is much in this assessment with which NASA can agree and which we believe establishes a compelling case for the Space Station Program. For example, the OTA assessment recognizes the need for three elements of longer-term space infrastructure.

These elements are: (1) a low-Earth orbit capability to assemble and checkout large and sophisticated satellites and space structures, (2) low-Earth orbit human residential and working space, and (3) a transportation staging facility. The Space Station capability which we are defining addresses all of these capabilities as well as others. In every important respect, including the maintenance of U.S. space leadership, the case for so-called "NASA baseline design" is illustrated. Definition studies will soon be underway to draw upon the expertise of industry culminating in a NASA baseline design replacing our current reference configuration. The capability comprised in the current NASA concept is driven by the requirements of users which have been collected and analyzed over the past three years. The key to the current concept is its versatility. Coupled with the capability to provide a permanently manned presence in space, the Space Station concept is compelling indeed.

b. A broad range of management options and approaches was examined by the NASA Space Station Task Force between 1982 and 1984 and the rationale for the option selected (as described in the answer to Question 9) is detailed in the report entitled "Space Station Management Plan and Procurement Strategy" prepared at the Committee's request and submitted in December 1984.

c. On the subject of formulating long-term national civilian space goals, the assessment endorses the National Commission on Space which chartered in NASA's FY 1985 Authorization Act. NASA is committed to support the activities of this Commission. It views this as an opportunity to review a rich agenda of potential future initiatives. NASA believes the Space Station is the logical follow-on to the Space Shuttle, and is the necessary precursor to future long range initiatives. It is, in fact, a necessary stepping stone to the major initiatives suggested for purposes of **discussion** in the OTA assessment.

QUESTION A-5:

How accurate is the NASA projected development and production cost of $8 billion? What are the implications of inaccuracy?

ANSWER A-5:

The NASA projected development and production cost of $8 billion (in FY 1984 dollars) was the result off an intensive effort by the Space Station Task Force's Concept Development Group (CDG). The CDG utilized the Space Station Cost Model, developed by the Marshall Space Flight Center, to perform both parametric cost estimates and cost trade studies of a variety of manned Space Station candidate concepts. The analyses performed by this model are based on actual (historical) hardware costs from recent manned space programs, including Shuttle and Spacelab.

During the definition phase, NASA and industry will develop more refined cost estimates based on detailed work breakdown analyses and prepare trade studies involving alternative cost and configuration comparisons.

QUESTION A-6:

What will be the annual cost of operating the Station and is adequate attention being given to designs that will minimize these costs?

ANSWER A-6:

We are very sensitive to how operating costs relate to overall systems design, operating philosophy, and system utilization. Since the outset of program planning, station operations has been given equivalent status with engineering, technology, and utilization. We fully intend to iterate the Space Station systems design against various operating and utilization scenarios to assure the most cost effective overall systems design. The cost categories will be evaluated as part of the overall system design studies during definition. NASA Center efforts are currently underway to develop and critique broadly defined operational scenarios, including the proposed participation by international organizations.

QUESTION A-7:

To what extent should the Space Station be automated?

ANSWER A-7:

The advanced Technology Advisory Committee (ATAC), established by Congressional direction, is in the process of producing the final draft of the Space Station Automation Report. The reports goals on the extent of automation for the Space Station state that the potential includes almost all systems and functions. The ATAC notes that there will be evolutionary progression towards the realization of a totally autonomous Space Station capability. The initial Space Station design will include a substantial degree of automation without precluding evolutionary growth. The subsystem designs will be targeted conceptually for the circa 2000 Space Station but simplified as necessary for the initial station, recognizing the readiness the technology and the lead time required to achieve an implementation.

QUESTION A-8:

Should the Station initially be permanently manned or merely man-tended?

ANSWER A-8:

Our objective is to provide a permanently manned Space Station. However, a man-tended approach is being studied as part of the definition studies. It is expected that operations in a man-tended phase would reduce early performance and defer costs. There is some reason to believe that a permanent manned facility which passes through a man-tended phase would be more expensive in the long run than a facility that did not have a man-tended phase of three to five years as has been suggested. The definition study will analyze and compare the different approaches and provide the data to determine the best approach in the long run to a permanently manned facility.

QUESTION A-9:

a. Could you describe the management approach planned for the Space Station?

b. Some have suggested that the "lead center" management approach on the Space Shuttle program contributed to the management and cost schedule problems. What are the lessons that were learned?

ANSWER A-9:

NASA has adopted a three-tiered structure for management that places responsibility for overall program direction in Headquarters, day-to-day program management and integration in a separate office at the Johnson Space Center, and development of major portions of the Space Station at the Goddard Space Flight Center, the Lewis Research Center, the Johnson Space Center and the Marshall Space Flight Center. Additionally, NASA concluded, after a thorough examination of options, that it should manage the systems engineering and integration (SE&I) of the program elements, but that the program must be managed in a way that would minimize restructuring of the Agency.

The Office of Associate Administrator for Space Station is responsible for the overall planning and direction of all elements of the Space Station Program (Level A).

The Space Station Program Office at the Johnson Space Center (Level B) is responsible for providing overall program management and integration. This includes integrating customer requirements, operations, and engineering (advanced development and work packages) functions into a cohesive program. Level B is responsible for defining the interfaces between work packages and for conducting the System Engineering and Integration for the program. This includes molding customer requirements, operations, and engineering (advanced development and work packages) functions into a cohesive program.

The Project Management Centers (Level C) are responsible for work package contract management, conduct of advanced development projects, providing SE&I support to Level B studies, and design, development and verification of all hardware and operations concepts. Each center work package will consist of a collection of functions that in any design or development activity will evolve into hardware, software, and interfaces.

Additional detail on the management of the Space

Station Program is contained in the report, Space Station Management Plan and Procurement Strategy, which NASA provided the Congress in December 1984.

b. In our approach to the management of the Space Station Program, we are making an earnest attempt to draw on the full depth of the Agency's experiences in managing large programs. Approaches that have worked well on large programs such as Mercury, Gemini, Apollo, and STS programs, as well as some aspects that did not work well, have provided lessons for current Agency management planning. The "lead-center" concept is inherently a sound concept as it places the responsibility for day-to-day management of an approved program at a development center, closest to the needed technical expertise. The lessons learned from previous programs are reflected by the following approaches by the Space Station Program management:

o A detailed program definition and preliminary design phase lasting approximately three years.

o A well-founded advanced development program to advance certain key technologies, thus reducing technical risks.

o Maximum emphasis on the involvement of the users in the early identification of customer needs and performance requirments.

o A Technical and Management Information System which will provide the communications needed among all levels of the Space Station Program and allow the distributed elements of the program to be coordinated.

QUESTION A-10:

In the past, NASA has spoken of an $8 billion ceiling on Station costs and you have spoken of "buying [the Station] by the yard," implying that if costs increase, less capability would be procured.

a. It now seems that the $8 billion has become a floor on costs. Is this correct?

b As we move into more commercialization of space, does it not make sense to put more emphasis on costs? That is, shouldn't we challenge our engineers with a tough cost ceiling as a way to begin to help industry into space?

ANSWER A-10:

a. Our bench mark estimate for the initial operating capability Space Station is still $8 billion (1984 dollars). The detailed definition we are conducting will provide a more thoroughly reviewed estimate upon which to scope the program.

b. We have and will continue to put emphasis on controlling Space Station costs. We are looking at annual operating costs as well as development costs. We are also working closely with the NASA Office of Commercial Programs in order to assure that we are sensitive to the importance of cost to the users. Within the Space Station Program Office, a commercial advocacy group has been formed as a focus for potential commercial Space Station activities.

QUESTION A-11:

Do you agree that the Space Shuttle will be the principal U.S. launch vehicle for a period of at least 20 years?

ANSWER A-11:

While a period of 20 years is difficult to forecast with a high degree of certainty. I believe the Space Shuttle will be the principal U.S. launch vehicle for at least the next decade. The planned use of Titan IIs by DOD and NOAA will reduce somewhat the Shuttle role as primary U.S. launch vehicle.

QUESTION A-12:

In your view, what is the likelihood that either increased launch traffic demand or an unforeseen accident will result in the need for a fifth Space Shuttle orbiter before the year 1995?

ANSWER A-12:

The Agency is not requesting a fifth orbiter vehicle in the FY 1986 budget. The probability of an major accident to one of the existing orbiters is small and structural spares are included in the program to minimize the impact of this type of event. Past studies, conducted by both internal and external groups, have reached the basic conclusion that the currently authorized four orbiter fleet can support the projected launch requirements at least through the end of this decade.

Should the need arrive, provisions have been made to keep the program in a posture which would not preclude the procurement of a fifth orbiter. The ongoing production program, the structural spares program, and the orbiter logistics program all provide a production capability base. The build time for an orbiter ranges between four to six years depending upon the need and funding.

QUESTION A-13:

If it is likely that a fifth orbiter will be required, what is to be gained from further delaying a production decision? Are such delays not driving up the ultimate cost of the vehicle?

ANSWER A-13:

NASA has assessed the need for a fifth orbiter through the late 1980's and has determined that the current orbiter fleet can meet requirements through that time frame. If a need for an additional orbiter is realized in the future the delay in building an orbiter could result in some added cost, which is estimated at approximately 10 percent, or $200 million, addition to the total cost the vehicle for each year's delay. However, we believe the cost increase has been minimized through the strategies we are following for structural and logistical spares. Additionally, in the long run, demonstrating a firm need for a fifth orbiter before embarking on its production is the most "cost prudent" way to approach this problem.

QUESTION A-14:

When will the loss of the contractors become so acute that it will be prohibitively expensive to initiate production of a fifth orbiter?

ANSWER A-14:

The structural spares program and the ongoing logistical program continues the critical orbiter contractors through FY 1986 without any major loss of capability. NASA will continue to study the need for a fifth orbiter as part of its FY 1987 budget deliberations.

QUESTION A-15:

Would it be possible to build the fifth orbiter slowly, over the next seven to eight years, and not seriously interfere with other NASA program funding requirements?

ANSWER A-15:

Our studies indicate it would be feasible to have a slow fifth orbiter built which would make the vehicle available in the 1993 time frame. Such a program would require funding of approximately $2.1 billion. Absorption of this within the Agency's budget level would have an impact on other NASA program funding requirements, including the considerations for other program initiatives.

QUESTION A-16:

Please summarize the current status of the Shuttle Pricing Policy deliberations that are now underway or the 1989-1991 time frame.

ANSWER A-16:

In accordance with NSDD 144, NASA submitted, on September 17, 1984, a plan for full cost recovery for foreign and commercial Shuttle operations for the 1989-1991 pricing period. The proposed plan is currently under review by the Senior Interagency Group (SIG) (Space) and the Cabinet Council on Commerce and Trade (CCCT).

QUESTION A-17:

When should this issue be fully resolved?

ANSWER A-17:

We hope that this issue will be resolved within the next two months. NASA is competing for several customers for launches scheduled in 1989 and beyond (i.e., INMARSAT INDIA and INTELSAT). These best and final offers must be made by June 1985.

QUESTION A-18:

Extended Duration Orbiter

We have been told by NASA that extending the Shuttle's on-orbit stay capability to in excess of 14 days would permit significant new research results to be achieved. Scientists have told us that such extensions would be "pure gold" and NASA has indicated that the cost of extending orbiter stay time to around 20 days could run as low as $78 million. Though the Space Station will, of course, permit much longer stay times, it will be limited to a single (probably 28 degree inclination) orbit. Would it not seem reasonable to make this modest investment in extending the orbiter's capability so that experimenters can conduct adequate research in polar or other orbits that are different from the one occupied by the Space Station?

ANSWER A-18:

Our most recent analysis has shown that to achieve an on-orbit extension to approximately 14 days would cost between $75 and $100 million. The changes required would take 2 1/2 to 3 years and could restrict Shuttle capability depending upon the particular modifications required. We have modified one of the orbiters with a fifth cryo kit, to extend its on-orbit time to 10 days. We also have plans to modify another orbiter to extend its capability to 10 days. At the present time, requirements for an EDO over 10 days are small, and, do not warrant the development of this capability.

For extensions beyond 20 days, studies have shown that the cost schedule and vehicle impacts would be very significant and not provide capabilities which could not be met more effectively by the Space Station. Additionally, the technical risk has been judged to be moderate to high.

We shall continue to search both for potential benefit from extended missions and for economical means to achieve mission extension to the orbiter's current capability.

"Fenced" Shuttle Operations

QUESTION A-19:

This past summer you announced the creation of a Shuttle Operations Strategic Planning Group that is to advise you on the extent to which Space Shuttle operations should be "fenced" from the rest of the planning group's activities and any conclusions that it may have reached.

ANSWER A-19:

This planning group focused its initial review on the current trends toward operational and market maturity and what they believe the status of the Shuttle will be in the next five to ten years. They have had fact finding meetings with those involved in Shuttle operations and market development, including representatives from NASA Headquarters, JSC, MSFC, and KSC as well as with the Air Force's Space Division at Los Angeles and Vandenberg and a number of private companies. The Group has been examining the wealth of material obtained during these meetings to assess the key alternatives for Shuttle operations and to develop its findings and conclusions. When the group has completed its report, it will be submitted to the Administrator for his use in the management of the Shuttle operations. NASA will keep the Committee apprised of the progress of this issue.

QUESTION A-20:

It would appear that OMV was NASA's highest priority new start candidate. Why is the OMV important?

ANSWER A-20:

The OMV is a critical element in future utilization of the full operational capabilities of the STS. The OMV is a reusable, remotely piloted vehicle that increases the "reach" of the STS by moving payloads to and from the STS. It moves these paylaods under ground control, freeing the Shuttle crew to perform other operations during payload transportation to and from the STS. It eliminates the need for STS energy and crew time in making these local stops. The OMV can, for reference, move a 5,000 pound satellite in a round-trip orbit altitude change of 1,200 nautical miles or effect about a seven degree orbit plane change, so it has quite a large orbital maneuvering capability.

The primary use of the OMV will be in bringing satellites to the Shuttle (or later Space Station) either for servicing by the crew or return to earth. In particular, the OMV is expected to play major roles in the Hubble Space Telescope (HST), Advanced X-Ray Facility (AXAF), and future earth observation, communications, and science spacecraft. Our recent success in saving three satellites, along with the logical expected increased in these mission operations that success brings, strongly supports a need for additional capability to bring and return future servicing "customers" to the STS. This is particularly true in polar orbit operations, where we will soon be operating through Shuttle launches from the Western Test Range (WTR). The Shuttle has much less payload capability from the WTR in polar orbit, since the rotation velocity of the Earth (available in the ETR equatorial orbit launches) is not available. The OMV will efficiently increase the orbit payload delivery/ retrieval capabilities of the STS for polar orbits.

The OMV also permits future launch of payloads from the STS without their own propulsion/fuel systems, thus reducing satellite cost. Some payloads, such as the potentially promising commercial materials processing application, do not want integral fuel tanks due to "slosh" perturbation; yet want periodic removal of products and resupply of materials. The OMV will perform these operations from the STS beginning in 1990 and be fully checked out to serve a major role with the STS in construction of the Space Station. We envision a need for a second OMV (identical to the first) to then be stationed at the operational Space Station for maneuvering operations, along with the original STS-based OMV which will handle orbits not accessible from the Station and its OMV.

QUESTION A-21:

When will the Orbital Maneuvering Vehicle be operational? What are the projected development costs?

ANSWER A-21:

The OMV will be operational in early 1990. Based on a contract start by April 1986, the OMV verification flight could be conducted as early as April 1990 and be available for space telescope servicing mission in that year, if required. The estimated development cost is in the $375-$450 million range, which includes one flight unit.

QUESTION A-22:

Does DOD have a number of applications for the OMV?

ANSWER A-22:

The DOD is currently assessing what utility the OMV might bring in support of National Security Missions. DOD funded a role assessment task in our definition phase contracts. Results of these assessments may be available in late summer or early fall after appropriate DOD reviews. Civil applications relative to generic satellite servicing functions such as deployment and retrieval may be of value to a number of DOD assets.

QUESTION A-23:

Is DOD planning to support the development of OMV? With funds? How much?

ANSWER A-23:

DOD has provided funds ($200 thousand-FY 1984) to support task in each system definition contract to assess the utility of an OMV to support National Security Missions.

QUESTION A-24:

How many OMV's will be required?

ANSWER A-24:

Our current NASA planning is for two flight units. The initial unit which is requested in the President's FY 1986 Budget is to be based on the STS orbiter. The second flight unit, which will based on the Space Station, will be funded by Space Station.

QUESTION A-25:

Please summarize the current status of NASA's efforts to privatize expendable launch vehicles.

ANSWER A-25:

In 1984, three companies submitted proposals to commercialize NASA's Expendable Delta and Atlas Centaur launch vehicle systems. General Dynamics Convair (GDC) proposed to take over the Atlas Centaur. Transpace Carriers proposed to take over the Delta vehicle system, and the Astro-Tech International (formerly Cyprus Corporation) proposed to utilize some Delta vehicle materials and tooling to produce a commercial upper stage they are considering offering to STS customers.

The current status of actions taken consist of General Dynamics Convair (GDC) being selected for operation of the Atlas Centaur program and an agreement is in the final stage of negotiation.

We have entered into a preliminary agreement in May 1984 with Transpace Carriers Incorporation (TCI) to establish the marketing of launch services on a commercial basis and initiate the production of launch vehicles in support of the commercial Delta program.

In the case of the Astro-Tech International regarding access to certain Delta production equipment to be used to modify a second stage of Delta as an upper stage with the Shuttle, steps are being taken by NASA to provide this access.

In addition, NASA will be soliciting proposals in 1985 from private industry for the commercial operation of the Scout Launch Vehicle. While Scout is operated by NASA, the prime use is the Air Force; they are evaluating their position on Scout usage: should the Air Force decide to continue with Scout, concurrent government and commercial operations could occur.

This overall effort is proceeding slowly. None of the potential commercial operators have been successful in their marketing efforts; they have not yet secured any signed missions.

QUESTIONS A-26:

How does ELV privatization interact with a decision on a fifth orbiter?

ANSWER A-26:

The decision on a fifth orbiter will depend primarily on flight planning requirements and the ability of our current orbiter fleet to meet these requirements. The impact of ELV privatization, which is in the early stages of development, has not yet become a factor in our consideration of the potential need for a fifth orbiter.

QUESTION A-27:

Please summarize the current status of DOD efforts to develop a Shuttle-equivalent expendable launch vehicle.

ANSWER A-27:

We understand DOD is continuing with its formal plans to select and acquire ten expendable launch vehicles, to be flown at the rate of approximately two per year, beginning in late 1988.

QUESTION A-28:

What are your views on this situation?

ANSWER A-28:

NASA agrees with the DOD requirement for a limited number of vehicles as described above.

QUESTION A-29:

What agreements have you reached with the Air Force on this matter?

ANSWER A-29:

NASA and the Air Force have proposed an agreement, which has been signed by the President to establish both the near term requirements, Air Force use of the Shuttle, and planning for the next generation of launch vehicles.

QUESTION A-30:

It is clear that the Space Shuttle development has had a major adverse impact on the health of the space sciences within NASA. If the science base -- mostly university researchers -- is not healthy, there is no point in flying missions.

With the prospect of a major Space Station developmental effort, how can we place the proper "fence" between Shuttle operations and Space Station development and this essential research base?

ANSWER A-30:

There is, in fact, no evidence that the shuttle development had a major adverse impact on the health of the Space Sciences within NASA. Over the history of the Agency, the fraction of the NASA budget devoted to Space Science has been relatively constant (including during the era of shuttle development) and major projects such as Space Telescope, Galileo, Ulysses, and the Gamma Ray Observatory were initiated. There is no reason to expect that either shuttle operations or Space Station development will have any adverse impact either. In fact, the Task Force on Space Station Science (under Chairman Peter Banks) has recently reached the conclusion that "the Space Station can be of great value to the advancement of space research."

QUESTION A-31:

In the area of International cooperation on space projects, historically NASA has found it necessary to begin negotiation with other countries prior to full program authorization and approval. Program deferrals or cancellations have often resulted in ill will. The present deferral of the International Solar-Terrestrial

Program (ISTP) is the latest example.

a. What mechanisms can you envision which would allow such negotiations to take place in good faith without the prospect of such cancellations?

b. What is the status of the ISTP Program?

ANSWER A-31:

a. The Office of Space Science and Applications (OSSA) has instituted periodic senior level program review meetings with both the Japanese Institute of Space and Astronautical Science (ISAS) and the European Space Agency (ESA). These meetings are attended by the OSSA Associate Administrator and the appropriate Division Directors. At these meetings the science program of each agency is discussed, the status of joint programs is updated and possible future cooperative programs are reviewed. With this mechanism the agencies stay apprised of the current progress and problems in order to avoid surprises. When problems are identified, both agencies can mutually determine a solution before ill will develops.

b. NASA is continuing its definition of an International Solar Terrestrial Physics Program. We have enlisted the collaboration of ISAS and ESA in order to maximize collaboration and scientific payoff from independent programs whose joint implementation would enhance the total scientific benefit. At present the ISAS portion of ISTP (Geotail Spacecraft) has been 1985 start date. A joint ISAS/NASA Science Working Group is defining the mission requirements. ESA has also recently approved a five percent per year increase in their mandatory science budget. Phase A studies are underway and involve joint ESA/NASA science advisory teams. A decision by ESA to go ahead with Solar Heliospheric Observatory (SOHO) and/or CLUSTER is expected by December 1985 for a January 1, 1987 start date. NASA is evaluating the potential provision of some scientific instruments, STS launches and Deep Space Network support for these ISAS and ESA missions. In addition, NASA is currently evaluating various mission scenarios involving up to three U.S. developed spacecrafts (WIND, EQUATOR and POLAR) as a part of an ISTP mission which will be a potential FY 1987 new start candidate.

QUESTION A-32:

We have recently heard of proposed cuts in the Headquarters staffing for science and applications.

a. Doesn't Headquartes have a valid assignment in running the science and applications programs?

Wouldn't the Centers have a conflict of interest, if they tried to run science programs (because the Centers compete with universities for funding support)?

b. In the past, you have staffed-up at Headquarters when development projects got into trouble -- most recently Space Telescope. We have some complex science development projects coming up. Aren't we setting ourselves up for more cost overruns and schedule delays if we don't have adequate Headquarters staff to oversee these projects?

ANSWER A-32:

a. NASA recognizes the responsibilities of Headquarters in the management of science and applications. The NASA Administrator recently reaffirmed the role of the OSSA and allocated an additional ten Civil Service billets and 30 rotating positions to be filled by highly qualified scientists and engineers from the universities and industry.

b. We agree that an adequate staff at Headquarters is essential to the successful execution of the complex science development projects. With the positions presently allocated, we believe that the staff will be able to provide the necessary oversight to the ongoing and planned projects and provide the leadership in the science and applications research programs.

QUESTION A-33:

It is pretty clear that the Shuttle and Spacelab programs have not provided many flight opportunities for science.

a. Is the problem due to a lack of Shuttle manifest space? Or is it due to lack of payloads?

b. The Spacelab program request is for about $270 million this year (spread across five programs) and has been at comparable levels for the past several years. What is this money for? Why is there a shortage of Shuttle science flight opportunities?

ANSWER A-33:

a. The Shuttle operational capability was somewhat later than originally planned, therefore fewer science payloads have been flown to date than originally planned; however, a substantial increase in the number of science payload opportunities is planned in the current as well as in future years.

b. Spacelab program funding is required for five primary activities: 1) mission management/Level IV integration including crew timeline planning, real time payload operations support, payload specialists training and integration of payloads into the Spacelab module and/or on pallets/special structures; 2) Physics & Astronomy instrument development for payloads such as Astro-1, Solar Optical Telescope, Solar High Energy Astrophysics Lab (SHEAL-1) and Space Plasma Lab; 3) Life Sciences flight experiments; 4) Materials Science and Applications payload development which includes the Materials Science Lab (MSL) series and various other payloads such as PACE, FES/VCG, etc; and 5) Earth Observations Mission (EOM) series. Based on current projection, adequate payload opportunities will be available in the current year and in future years for science and applications payloads.

QUESTION A-34:

The Landsat Commercialization Act of 1984 directed NASA to enhance its remote sensing R&D effort.

a. What level of funding did you have in 1984? In 1985?

b. What is your request for 1986?

c. Have any programs been terminated?

d. This is potentially an area of great benefit to mankind. What is NASA doing to realize this potential?

ANSWER A-34:

Although NASA's remote sensing R&D efforts span a broad range of activities in specific sensor technologies as well as utilization of the data in a variety of earth science disciplines, we have assumed that this question is directed toward those endeavors intended to (1) improve existing capability and (2) introduce new techniques in studying land surface phenomena. The main thrust of this effort is implemented through the Shuttle/Spacelab payload development. This funding level was $16 million in FY 1984, $12 million planned to be spent on these activities in FY 1985 and $23 million planned in FY 1986. The emphasis of this program has been and continues to be an effort to develop a capability to perform all-weather imaging of the land surface through active remote sensing with synthetic aperture radar and to improve the passive sensors through the incorporation of solid state detectors.

The SIR-B instrumentation was successfully flown in October 1984, and provided a set of data that will allow an evaluation of the L-band wavelengths at multiple incidence angles to determine the information content for surface structure and vegetation at these multiple "look" angles. In the future we are planning a reflight to provide additional scene variety, and later to upgrade the system to include a C-band wavelength to assess the effects of varying this parameter.

In the case of passive remote sensing, two approaches were being pursued. One approach was to re-design a Thematic Mapper-type instrument to incorporate solid state detector technology, provide for off-nadir viewing and to accomplish a flight test program in short-duration Shuttle flights as an attached payload. The other approach was to take the more advanced step toward an imaging spectrometer that could provide narrow wave-length interval data from the visible into the infrared portion of the spectrum with approximately 128 channels. A decision was made in September 1984 to eliminate the flight test program of the first approach, but to continue the subsystem technology to a level of maturity to assure readiness for incorporation into a thematic mapper class instrument. We plan to focus our flight hardware development activities on an imaging spectrometer device with a flight of this device in the early 1990's time frame.

As to the future benefits of remote sensing, we recognize the power of this capability in the assessment of global processes as well as its contribution to site specific studies, therefore, we commissioned the Earth Systems Sciences Committee (ESSC) to advise NASA on the pressing science issues and questions that lend themselves to study through remote sensing from space and to recommend a plan. We have requested that the plan be completed by early 1986 for our use in formulating a focused NASA program while communicating the views of the scientific community in this field. Concurrently and in consonance with the ESSC, we initiated definition of integrated remote sensing systems that will capitalize on the capability offered by the Space Station. We have produced an initial report on the science requirements for such a system and are continuing to define system support requirements and the supporting infrastructure to produce a total geo-based information system.

QUESTION A-35:

Space Telescope will launch in the second half of 1986, i.e., maybe after the end of FY 1986.

a. There is $86 million in the FY 1986 budget for Space Telescope Operations. What does this go for?

b. The Agency is planning several science facilities that will have to be operated for many years. (ST, GRO, AXAF, SIRTF, Station). Will operating costs consume the whole budget? Has the Agency begun to deal with this problem?

ANSWER A-35:

a. The FY 1986 funding request of approximately $86 million provides for both Operations and Maintenance/ Refurbishment and provides for the following Hubble Space Telescope (HST) activities:

1) HST Operations funding ($57.3 million in FY 1986) provides for:

- The system development activities, both hardware and software to support all types of science,
- The Mission Operations Control Center at GSFC: staffing, science planning, etc.
- The Science Institute: development activities, staffing, science planning, etc.
- Science Program: support to PI's and Co-I's

It is important to note that although the launch is scheduled for the second half of 1986, the control center operations personnel must be in place for pre-launch training, testing, and other pre-launch events required prior to launch.

2) Maintenance and Refurbishment ($30.7 million in FY 1986) provides for:

- Second Generation Science Instruments, and Command and Data Handling System
- Orbital Replacement Units
- Support Service Equipment
- Orbital Maintenance Preparations
- Systems Engineering

b. NASA has initiated studies of the operation of its space observatories (ST, GRO, AXAF, and SIRTF) to identify and define the most cost effective operations procedures. These studies involve examination of scope, implementation modes, and commonality of approach and resources which can be effected. The portion of the budget devoted to operations will be determined in part by the results of these studies. We do not believe that operation of these facilities has to consume an excessive portion of the budget, although we do currently share your concern.

QUESTION A-36:

What are NASA's plans in 1985 for the following missions that have been around for a long time?

a. Advanced X-Ray Astrophysics Facility (AXAF)
b. Space Infra-Red Telescope Facility (SIRTF)
c. Solar Optical Telescope (SOT)
d. Ocean Topography Experiment (TOPEX)
e. Gravity Probe-G (GP-B)

ANSWER A-36:

NASA's current plan for the missions are to continue definition activities in FY 1985 with the following plans for potential initiation:

a. Advanced X-Ray Astrophysics Facility (AXAF) - Candidate for new start in FY 1987.

b. Space Infrared Telescope Facility (SIRTF) - Candidate for new start in FY 1989.

c. Solar Optical Telescope (SOT) - Planned development start around June 1985.

d. Ocean Topography Experiment (TOPEX) - Phase B studies have been completed. Satellite definition studies will be continued by Fairchild, RCA, and Rockwell. Brassboard development of the TOPEX altimeter will be continued at the Applied Physics Laboratory. Joint definition/technical feasibility studies will be reviewed so as to further detail the collaborative responsibilities and interfaces involving CNES and NASA in pursuing the TOPEX/POSEIDON initiative. These activities are being conducted to prepare TOPEX for consideration as a potential FY 1987 New Start.

e. Gravity Probe-B (GP-B) - Candidate for FY 1987 development start of a technology demonstration test flight on the shuttle.

QUESTION A-37:

In your statement (page 6) you refer to your Advanced Communications Technology Satellite (ACTS) program and state that it will "demonstrate the technology needed for the United States to remain competitive in this important area". As your statement would seem to confirm, ACTS is the kind of technology that would be difficult for a Less Developed Country (LDC) to use. For example, ACTS needs a very sophisticated, computerized central ground station to run the system.

a. Will ACTS help the LDCs?

b. Is NASA developing technology which will both be available to LDCs and also help relieve orbit and spectrum crowding?

c. Do you believe, from the point of view of an LDC, that technology will solve the problem of orbit and spectrum crowding?

d. Who in the United States is in charge with this problem?

ANSWER A-37:

a. ACTS technology is applicable to the needs of less developed countries. Implemented in the C or Ku band, ACTS can provide network control, interconnectivity and access capability with small earth terminals and relatively straight-forward master control stations. This capability is especially important in areas of the world which have few existing communications facilities.

b. The ACTS project is developing advanced technologies which will relieve orbit and spectrum crowding and provide for dynamic allocation of network resources to match growing countries' needs.

c. The ACTS technology will make substantial contribution to solving the problem of orbit and spectrum crowding.

d. The Department of State is in charge of setting policy with respect to telecommunications outside the U.S. The National Telecommunications and Information Agency (NTIA) and the Federal Communications Commission (FCC) also have responsibility to domestic policy and regulation. NASA is the only civilian agency developing advanced communications technology.

QUESTION A-38:

NASA's budget request for commercialization in FY 1986 is $30 million, a significant increase over last years' $8.5 million. Can you highlight what NASA's major emphasis will be in the commercialization area?

ANSWER A-38:

The FY 1986 funding request of NASA's Office of Commercial Programs will build upon the commercial use of space activities initiated in FY 1985. In seeking a greater private sector commitment of resources to commercial space research and development, NASA's FY 1986 commercial program budget request will support the commercial development of space in the following areas:

Centers for The Commercial Development of Space (CCDS): NASA will continue funding of CCDS research centers to accelerate the process of moving ideas developed through basic research into the commercial space marketplace. As in FY 1985, NASA will furnish funding for three to six centers at an annual funding rate between $500,000 and $1 million per center.

Stimulating NASA Research with Commercial Potential: NASA can facilitate the commitment of private resources to commercial space endeavors by enabling industry to have an input in setting NASA's research agenda, and by conducting research with commercial space applications. In FY 1986, NASA will use mechanisms such as the NASA Advisory Council to assure that NASA R&D is responsive to the trend toward the commercial use of space, and fund commercial space research projects sponsored by NASA field centers.

Stimulating Private Sector Commercial Research: NASA funding of private sector commercial space research will help to reduce the up-front risks and costs of basic research that will support commercial space endeavors. The NASA Small Business Innovation Research Program is one mechanism that will be used to stimulate private sector commercial research.

Increasing the Availability of NASA Facilities and Equipment: In FY 1986, NASA will continue to enable industry and university researchers to consider space flight experimentation without major investments in highly specialized equipment. NASA seeks to expand the availability of facilities such as furnaces, optical fiber production devices, and protein crystal growth devices.

Outreach: NASA will seek to enhance NASA's links with industry, universities, and the financial and insurance communities through mechanisms such as researcher exchange programs and seminars.

QUESTION A-39:

You have recently established a NASA Office of Space Commercialization as well as a number of policy guidelines.

a. Could you elaborate on what you consider the most important policy consideration to enhance commercialization activities?

b. Is NASA planning to use the procurement process to encourage space commercialization? Within a normal Source Evaluation Board process is it appropriate to give extra points for private investment to offset any negative evaluation NASA might perceive associated with a commercially developed system?

ANSWER A-39:

a. NASA policies will consider reasonable innovations for identifying, encouraging, facilitating, and coordinating agency actions to stimulate the commercial use of space. An important feature of NASA's Commercial Use of Space Policy is to open access to NASA developed space technology and capabilities. NASA's objective is to stimulate and increase the level of private investment in commercial space endeavors. NASA will support innovative marketing techniques on behalf of commercial research and technology projects.

b. To the best of our knowledge, the procurement statutes do not provide for giving preferential treatment to a class of offerors under these conditions. This form of reference is essentially directed only to labor surplus area firms and small disadvantaged businesses. For these reasons, the Source Evaluation Board process contemplates a thorough appraisal of offers bearing on the probability of quality performance, realistic cost estimating and pricing, logic of proposed performance, and management of projects. Selection criteria, in our judgment, must be chosen carefully enough to apply equally to all offerors and support free and open competition in regard to the technical necessities of the requirement.

NASA will use the government procurement process with the criteria established above and other relevant existing criteria to encourage private investment in space.

QUESTION A-40:

As a major initiative of NASA's Commercial Use of Space

Policy involves establishing Centers for the Commercial Development of Space.

a. Can you elaborate on the makeup and function of these centers, and projected funding requirements?

b. How will these centers differ from "Centers of Excellence" sponsored by NASA?

ANSWER A-40:

a. NASA's Centers for the Commercial Development of Space are to be joint undertakings involving, to the extent practicable, teams of non-profit institutions, universities, industry, and NASA centers. NASA will provide support to these Commercial Development research centers through funding and technical assistance. Overall administration of the Centers will be the responsibility of the Commercial Development Division within the Office of Commercial Programs. NASA's current plan is to fund three to six Centers at an annual rate of between $500,000 and $1 million.

b. The primary difference between the efforts is one of focus. Centers for the Commercial Development of Space will focus on research aimed at processes with commercial potential, with the basic science becoming a secondary objective. This focus is reversed with the Centers of Excellence in the Space Science and Applications program.

QUESTION A-41:

NASA has indicated that a portion of funds in the Office of Commercial Programs will go to support research with potential commercial value.

a. What research areas has NASA identified for such support?

b. How will funding be provided? Will available funds supplement research funding available in other programs?

ANSWER A-41:

a. Working with aerospace and non-aerospace companies, NASA has identified a number of primary research areas utilizing the unique attributes of space which may lead to commercial space ventures. Examples of these research areas are electronic materials, biotechnology, fluid dynamics, glass and ceramics, metals and alloys, chemistry and physics materials processing, associated process control technology, earth and ocean observation, communications, life sciences, space technology, and materials processing.

b. NASA's Office of Commercial Programs will fund NASA research with commercial potential. NASA believes that private sector seed funding is best handled through the Small Business Innovation Research Program.

NASA--sponsored research with commercial potential, which may supplement research funding available in other NASA programs, will be funded through procedures similiar to the Research Technology Operating Plan (RTOP) process.

QUESTION A-42:

What is NASA doing to increase the pipeline of payloads that will fly on the Shuttle?

ANSWER A-42:

NASA's efforts to increase the opportunity for payloads to fly on the Shuttle include streamlining the process of qualification and integration of payloads, standardizing payload criteria and technical requirements, and increasing the availability of support equipment to reduce procedural barriers and costs. In order to achieve this increase in pipeline flow, it is necessary to conduct precursor activities focused on the potential users and customers.

The Office of Commercial Programs is contributing to these efforts through initiatives such as Outreach, new market development, and Centers for the Commercial Development of Space.

A key objective of the Outreach Program is to enable NASA to better understand industry's research priorities and facilitate timely dissemination of NASA research data. Outreach mechanisms being considered by the Commercial Programs Office that can result in greater utilization of Shuttle include:

o Technical Workshops: NASA and industry sponsored workshops in particular technology areas can help familiarize industry researchers with on-going NASA research with commercial potential.

o Commercial Space Data Dissemination: Through a centralized approach to managing experimental NASA data with commercial potential, the Office of Commercial Programs can facilitate private sector participation in space flight experimentation.

New market development efforts involve meeting with contractor-supplied customers and determining their needs. Customers are then exposed to the NASA field centers where experiments of interest to them are conducted. This effort will help to develop a program of mutual interest which can lead to commercial flights on the STS by the customer.

The objective of NASA's Centers for the Commercial Development of Space (CCDS) is to stimulate high technology research directed to the development of projects in space which have commercial potential or will contribute to possible commercial ventures. Through the CCDS process, NASA anticipates that government facilities and flight opportunities will be made available through Joint Endeavor or Technical Exchange Agreements.

QUESTION A-43:

What role does NASA play on the Cabinet Council on Commerce and Trade?

a. What is NASA's role on the Cabinet Council's Task Force on Commercialization?

ANSWER A-43:

NASA's involvement with the Cabinet Council on Commerce and Trade (CCCT) is limited to those CCCT deliberations involving space policy issues. NASA had a role in CCCT deliberations on Space Station and Landsat commercialization.

a. The NASA Deputy General Counsel serves as Vice-Chairman of the CCCT Commercial Space Working Group.

QUESTION A-44:

The FY 1985 NASA Authorization, signed into law last July, directed the President to establish a National Commission of Space to help formulate long-range goals for civilian space policy over the next 20 years. The one-year commission was to be established within 90 days of enactment, and in fact the President issued an executive order establishing the Commission, yet Members have not as yet been named.

a. What is the current status of the National Commission on Space?

b. Can we expect the "Commissioners" to be named shortly?

ANSWER A-44:

On October 12, 1984, Executive Order 12-490 established a National Commission on Space. Members other than the four members from Congress have not been named as of yet.

QUESTION A-45:

Commercial, military, and other government (including NASA) demand for the Shuttle is currently below what market studies in the 1970's had projected for today.

- Commercial market demands are right on target to 1970 projections;
- Military market demands are less than 1/3 of projections made in the mid 1970's;
- Other government (including NASA) demand is down.

What would you say is the primary reason for the shortfall of non-military government market demands from those that had been projected in the mid 1970's?

ANSWER A-45:

The single largest shortfall in the civil government demand for Shuttle launches arises from assumptions of Spacelab use in the 1980's. As late as 1977 when a special study was conducted at an OMB request, about 279 Spacelab flights or 51 percent of all flights were projected for the first twelve years of Shuttle operations. These included 29 Spacelab flights for ESA, the builder of Spacelab, and 20 flights for U.S. commercial customers. Today the anticipated number of total Spacelab missions for the twelve years is 40 flights including six commercial and foreign (ESA) flights.

Spacelab is still perceived as a viable mode of accommodating man and instruments for space research by government and industry alike. However, launch costs combined with the cost of instruments and system integration have resulted in considerably less Shuttle traffic than anticipated throughout the 1970s'

An adjustment of the Spacelab missions from the total Shuttle traffic of the 1977 OMB Study to today's Spacelab level and adjusting for DOD projections (a reduction of about 25 flights) brings the projections of the 1970's into line with the current anticipated use of the Shuttle or a reduction from 552 flights to about 250 flights.

QUESTION A-46:

Last year, NASA projected that the FY 1986 budget would total $7.914 billion. Within this figure, there was something like $280 million or the Space Station as well as a planning wedge that would permit some new program starts in the Space Science and Applications area and provide production funds for the Orbiter. The FY 1986 budget that the President has just submitted has a bottom line total that is only $28 million below last year's projection, however:

The Space Station program has been reduced by about $50 million;

There are no new program starts in the Space Science and Applications area;

There are no new production funds for the Orbiter; and,

The agency is cutting its staffing level by 200 people.

Can you explain what happened to the funds contained in the planning wedge that was in last year's FY 1986 budget projection?

ANSWER A-46:

There have been a number of changes in the NASA program plan and funding requirements since preparation of the FY 1985 budget. The planning wedge in last year's projection has enabled us to cover these changes within the approved budget level. Among these changes are the following:

1) Shuttle Operations funding requirements have increased as a result of the net effect of reduction in the amount of anticipated reimbursements, both from the Department of Defense and foreign and commercial users, and the savings which can be realized from changes of the flight mission schedule and other cost reduction activities;

2) Advanced Communications Technology Satellite flight program activity and the Advanced Turboprop flight test phase have been added to the program consistent with Congressional direction;

3) Provision has been made for an early payment to the Federal Financing Bank in FY 1986 consistent with Congressional guidance to make such payments to reduce interest cost;

4) Funding for activities to encourage commercial use of space has been included;

5) Provision has been made for Upper Stages for the Advanced Communications Technology Satellite and the sixth Tracking and Data Relay Satellite;

6) Development of the Orbital Maneuvering Vehicle is planned for initiation in FY 1986; and,

7) Materials Processing research and development activities have been augmented, provisions have been made to begin preparation for the Voyager encounter with Neptune, and funding has been added to sustain tracking station operations as a result of delay in the TDRSS launch schedule.

QUESTION A-47:

When you appeared before our committee part of your response to a question on costs of operations of science missions referred to terminating some of those missions.

a. Which missions are you considering terminating?

b. What other approaches to reducing costs are you considering?

ANSWER A-47:

a. Each year a review of operational missions is conducted to determine whether each mission should continue or be terminated. The criteria for determining whether a mission should be continued or terminated is based on such considerations as the amount of new data being returned, its importance to ongoing or new missions, and the associated cost of continuing each mission. As you know, the major cost of a science or applications mission is incurred during the development phase, therefore we believe that we should maximize the data return. In some cases, after having accomplished a mission's prime objective within the initial operating life, we have been able to accomplish new mission objectives by using hardware already in orbit. For example, ISEE-3 was used for five years to monitor the solar winds and magnetosphere; however we later determined that we could change the orbit of the very productive spacecraft to acquire new science objectives; which involves acquiring data on the Ciacobini-Zinner comet. This mission will, at a relatively small investment, provide important data on comets that will not only be valuable to the research scientists but will provide invaluable data needed for potential future missions which will study comets.

b. NASA is always seeking to minimize cost through the careful selection of the mission objectives and the use of existing technology and hardware. We are considering such innovative approaches as the use of leased platform services to fly the EUVE mission instead of building a new dedicated spacecraft. We are also planning to take advantage of the Space Shuttle's ability to repair and refuel in orbit for all appropriate future missions. This on-orbit servicing was demonstrated on the Solar Maximum Repair Mission, and has been included in the Space Telescope design. This concept will be a major consideration in all future missions.

QUESTION A-48:

Our staff has had an opportunity to review your Civil Missions Advisory Board's Report that suggests that in the 1990's and beyond, manned missions, as well as other NASA missions, could require several hundreds of kilowatts of electric power, such as could be made available using nuclear reactors. NASA has participated in the development of the so-called 100 kilowatt class nuclear reactor systems through the SP-100 Program. Does the Agency plan to continue its activities in support of the development of nuclear power systems for space in FY 1986 and beyond?

ANSWER A-48:

The Civil Missions Advisory Group (CMAG) report concluded that there are missions of interest, potentially launched in the first decade of the next century, which could be significantly enhanced if a nuclear power source were available.

NASA is participating with DOE and DOD in the SP-100 Program technology assessment and advancement phase. NASA intends to continue its support of this program with its long term potential to civil missions usage in view. In the next phase of the SP-100 Program, presently scheduled to start in FY 1986, the planned NASA activities are:

1. continue civil missions analysis and requirements definition;
2. management of non-nuclear advanced technology activities parallel with ground engineering systems (GES) development;
3. management of selected GES technology developments as appropriate to NASA capabilities; and,

4. ad hoc technical support of GES development efforts.

QUESTION A-49:

Mr. Beggs, as you may know, I am very supportive of the SDI in the R&D phase. I hope that NASA will support the space power programs with SDI since they have such a unique capability; analytical and experimental, in these power systems technologies. What is your view on NASA's role?

ANSWER A-49:

NASA presently supports the Strategic Defense Initiative (SDI) power programs through participation in the Tri-agency SP-100 space nuclear power program. In addition, the NASA Lewis Research Center is supporting the SDI Multi-Megawatt Power Program with an assessment of space power system concepts and components, development of R&T plans, and power systems modelling.

In the future, NASA will continue its participation in the SP-100 program and will support the SDI in other power technologies where we have expertise and interest.

QUESTION A-50:

In Fiscal Year 1985, NASA was directed to apply an additional $2 million of its authorized budget to the SP-100 Program. It is my understanding that the Agency does not plan to heed this direction. Mr. Beggs, am I correct in this understanding? And if so, could you please explain.

ANSWER A-50:

In response to the FY 1985 authorization directive, the ongoing technology assessment and advancement phase (Phase I) activities were carefully assessed. The assessment showed that the Tri-agency funding level would support the research planned to be completed by July 1985 in support of system concept selection. Therefore, NASA does not plan to increase the SP-100 funding in FY 1985 by the $2 million authorized.

QUESTION A-51:

Mr. Beggs, my Subcommittee, over the past two years or so, has received testimony that suggests NASA's participation in the development of nuclear power systems for space is critical to its success. I have heard some conflicting reports that suggest certain people within the Agency do not see a need for nuclear power for NASA's planned activities long into the distant future, say beyond the year 2000. Others, however, within the Agency, suggest that nuclear power may well be a significantly enabling technology to assure the success of potential NASA missions of the 1990's and beyond. Could you clarify NASA's position regarding the future implementation of the nuclear power option for civilian space missions for the Committee?

ANSWER A-51:

The Civil Missions Advisory Group (CMAG) studies highlighted civil space missions in the 1990's and beyond that could be enhanced to some degree by the availability of nuclear reactor power source. In several missions that fall beyond 2000, the CMAG report indicated that the performance enhancement is very significant and possibly enabling. A mission in this class might be the Comet Rendezvous and Sample Return. I believe the CMAG report addresses fully this area of Subcommittee concern.

NASA will continue to support the timely advancement of nuclear technology with long term applicability to civil missions usage in view. Potential civil mission requirements will continue to be analyzed.

Responses to Questions submitted by Honorable Harold L. Volkmer.

QUESTION 1:

Please furnish the following tabulation, by major programs, for the FY 1986 budget request:

a. the original recommended budget to OMB,
b. the adjustments made,
c. the submission to Congress,
d. brief comment on the adjustments made, i.e., a description of corresponding program impacts or changes,
e. the comparative FY 1985 operating plan figure,
f. please assign an agency priority to those programs requested from OMB but not presented to Congress.

ANSWER 1:

See Table A attached.

TABLE A

COMPARISON OF OMB BUDGET REQUEST TO CONGRESSIONAL BUDGET REQUEST

	FY 1985 CURRENT ESTIMATE	FY 1986 BUDGET REQUEST TO OMB	△	FY 1986 BUDGET REQUEST TO CONGRESS	REMARKS
RESEARCH AND DEVELOPMENT	2422.6	3000.1	-118.3	2881.8	
SPACE STATION	150.0	280.0	-50.0	230.0	Reduced funds for advanced technology studies and systems definition effort
SPACE TRANSPORTATION CAP DEV	351.4	458.4	0.9	459.3	Internal update and realignment of estimates
SCIENCE AND APPLICATIONS	1404.5	1645.2	-32.0	1613.2	
PHYSICS AND ASTRONOMY	677.2	642.4	-12.0	630.4	
HUBBLE SPACE TELESCOPE DEV	195.0	127.8	0.0	127.8	
GAMMA RAY OBSER DEV	117.2	87.3	0.0	87.3	
SPACELAB PAYLOAD DEV & MSN MGMT	105.4	135.5	0.0	135.5	
GRAVITY PROBE-B FLIGHT DEMO	0.0	12.0	-12.0	0.0	Deletion of funds for proposed augmentation
EXPLORER DEVELOPMENT	51.9	55.2	0.0	55.2	
MISSION OPNS & DATA ANALYSIS	109.1	119.9	0.0	119.9	
RESEARCH AND ANALYSIS	39.9	42.3	0.0	42.3	
SUBORBITAL PROGRAM	58.7	62.4	0.0	62.4	
LIFE SCIENCES	62.3	72.0	0.0	72.0	
FLIGHT EXPERIMENTS	27.1	33.4	0.0	33.4	
RESEARCH AND ANALYSIS	35.2	38.6	0.0	38.6	

TABLE A

COMPARISON OF OMB BUDGET REQUEST TO CONGRESSIONAL BUDGET REQUEST

	FY 1985 CURRENT ESTIMATE	FY 1986 BUDGET REQUEST TO OMB	△	FY 1986 BUDGET REQUEST TO CONGRESS	REMARKS
PLANETARY EXPLORATION	290.9	359.0	0.0	359.0	
GALILEO DEVELOPMENT	56.1	39.7	0.0	39.7	
ULYSSES	9.0	5.6	0.0	5.6	
VENUS RADAR MAPPER MISSION	92.5	112.0	0.0	112.0	
MARS OBSERVER	13.0	43.8	0.0	43.8	
MSN OPNS & DATA ANALYSIS	58.8	95.0	0.0	95.0	
RESEARCH AND ANALYSIS	61.5	62.9	0.0	62.9	
SPACE APPLICATIONS	374.1	571.8	-20.0	551.8	
SOLID EARTH OBSERVATIONS	57.6	74.9	0.0	74.9	
SHUTTLE PAYLOADS	12.1	23.1	0.0	23.1	
RESEARCH & ANALYSIS	15.6	20.1	0.0	20.1	
GEODYNAMICS	21.9	23.2	0.0	23.2	
LASER NETWORK OPNS	8.0	8.5	0.0	8.5	
ENVIRONMENTAL OBS	212.7	337.5	-20.0	317.5	
RESEARCH AND ANALYSIS	96.6	102.7	0.0	102.7	
SHUTTLE PAYLOADS	7.8	5.6	0.0	5.6	
TETHER PAYLOADS	3.0	4.5	0.0	4.5	
EARTH RADIATION BUDGET EXPERIMENT	8.1	2.0	0.0	2.0	
UARS MISSION	55.7	134.0	0.0	134.0	
SCATTEROMETER	12.0	31.7	0.0	31.7	
OTHER ENVIRONMENTAL OBS	29.5	57.0	-20.0	37.0	Deletion of funds for proposed Ocean Topography Experiment initiative

TABLE A

COMPARISON OF OMB BUDGET REQUEST TO CONGRESSIONAL BUDGET REQUEST

	FY 1985 CURRENT ESTIMATE	FY 1986 BUDGET REQUEST TO OMB	△	FY 1986 BUDGET REQUEST TO CONGRESS	REMARKS
MATERIALS PROCESSING	27.0	34.0	0.0	34.0	
COMMUNICATIONS	60.6	106.2	0.0	106.2	
SEARCH & RESCUE	2.4	1.3	0.0	1.3	
ACTS	45.0	90.0	0.0	90.0	
OTHER COMMUNICATIONS	13.2	14.9	0.0	14.9	
INFORMATION SYSTEMS	16.2	19.2	0.0	19.2	
TECHNOLOGY UTILIZATION	9.5	11.1	0.0	11.1	
COMMERCIAL USE OF SPACE	(8.5)*	30.0	0.0	30.0	
AERONAUTICAL RSCH & TECH	342.4	391.2	-37.2	354.0	
AERO RSCH & TECH BASE	223.3	246.5	-7.2	239.3	General reduction
SYSTEM TECH PROGRAMS	119.1	144.7	-30.0	114.7	Termination of advanced composite structures program and reduction in the effort on Turbine engine hot section technology

* - IN FY1985, FUNDED AS PART OF THE OFFICE OF SPACE STATION ($0.2 MILLION), OFFICE OF SPACE FLIGHT ($4.5 MILLION), OFFICE OF SPACE SCIENCE AND APPLICATIONS ($2.0 MILLION), OFFICE OF AERONAUTICS & SPACE TECH ($0.7 MILLION) AND OFFICE OF SPACE TRACKING AND DATA SYSTEMS ($1.1 MILLION).

TABLE A

COMPARISON OF OMB BUDGET REQUEST TO CONGRESSIONAL BUDGET REQUEST

	FY 1985 CURRENT ESTIMATE	FY 1986 BUDGET REQUEST TO OMB		FY 1986 BUDGET REQUEST TO CONGRESS	REMARKS
SPACE RESEARCH & TECHNOLOGY	150.0	168.0	0.0	168.0	
SPACE RSCH & TECH BASE	136.3	140.0	0.0	140.0	
SYSTEMS TECH PROG	8.8	20.0	0.0	20.0	
STANDARDS & PRACTICES	4.9	8.0	0.0	8.0	
TRACKING AND DATA ADVANCED SYSTEMS	14.8	16.2	0.0	16.2	
SPACE FLIGHT CONTROL AND DATA COMMUNICATIONS	3601.8	3541.6	-31.7	3509.9	
SHUTTLE PROD & OPERATIONAL CAP	1492.1	976.5	0.0	976.5	
SPACE TRANSPORTATION OPS	1314.0	1726.0	-0.9	1725.1	Realignment of Space Transportation Systems estimates
SPACE & GROUND NETWORK, COMM & DATA SYSTEMS	795.7	839.1	-30.8	808.3	Reduction in FFB prepayment for TDRSS and general reduction
NATIONAL SECURITY LAUNCH ASSURANCE	—	50.0	-50.0	—	Funds not included for proposed activity
CONSTRUCTION OF FACILITIES	150.0	168.3	-19.0	149.3	Deletion of funds for modification to Altitude Wind Tunnel
RESEARCH AND PROGRAM MANAGEMENT	1336.3	1428.0	-83.0	1345.0	Reduction in R&PM base to reflect 5% governmentwide reduction in civil service salaries and benefits, the reduction of 200 FTE's and other support costs related to President's Management Improvement Initiative, deletion of funds for proposed augmentation of administrative ADP operations
TOTAL NASA	7510.7	8188.0	-302.0	7886.0	

QUESTION 2:

Please furnish the following information, by NASA enter and by major program, for the FY 1986 budget request:

a. original Center request to NASA Headquarters,
b. the adjustments made,
c. brief comments on adjustments made,
d. the submission to Congress as allocated by Center, and
e. the comparative FY 1985 operating plan figure, by Center.

ANSWER 2:

See Table B attached.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 BUDGET REQUEST
RESEARCH AND DEVELOPMENT/SPACE FLIGHT, CONTROL AND DATA COMMUNICATION

JOHNSON SPACE CENTER
(Millions of Dollars)

	FY 1985 CURRENT ESTIMATE	FY 1986 CENTER REQUEST	Δ	FY 1986 BUDGET REQUEST	REMARKS
SPACE STATION	42.3	224.5	-112.6	111.9	Advanced development tasks deferred and reassigned, systems definition funds transferred to other Centers.
STS CAPABILITY DEVELOPMENT	113.2	141.1	-26.0	115.1	Reduced funds for Engineering and Payload Support and Spacelab effort. Deleted Aft Flight Deck processor.
SHUTTLE PROD & OPS CAPABILITY	741.4	494.4	-123.0	371.4	Reduced spares requirements, deleted fourth Shuttle training aircraft, aft visual simulator and advanced spacesuit project.
STS OPERATIONS	382.9	619.7	-81.0	538.7	Reduced number of flights, reduced flight spares requirements and incorporated savings for consolidated flight equipment contracts.
PHYSICS AND ASTRONOMY	0.4	9.5	0.0	9.5	
LIFE SCIENCES	22.0	26.5	0.0	26.5	
PLANETARY EXPLORATION	10.3	11.1	0.0	11.1	
SPACE APPLICATIONS	3.9	4.1	0.0	4.1	
TECHNOLOGY UTILIZATION	0.2	0.3	0.0	0.3	
AERONAUTICAL RESEARCH & TECHNOLOGY	1.0	1.0	0.0	1.0	
SPACE RESEARCH AND TECHNOLOGY	11.7	11.6	0.0	11.6	
COMMERCIAL USE OF SPACE	(1.0)	7.3	-5.7	1.6	Reduction of funds for proposed activities.
SPACE & NETWORK COMMUNICATION & DATA SYS	0.1	--	0.0	--	
TOTAL	1357.4	1551.1	-348.3	1202.8	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 BUDGET REQUEST
RESEARCH AND DEVELOPMENT/SPACE FLIGHT, CONTROL AND DATA COMMUNICATION

MARSHALL SPACE FLIGHT CENTER
(Millions of Dollars)

	FY 1985 CURRENT ESTIMATE	FY 1986 CENTER REQUEST	△	FY 1986 BUDGET REQUEST	REMARKS
SPACE STATION	34.9	53.4	-8.0	45.4	Reduced funds for Advanced Development tasks.
STS CAPABILITY DEVELOPMENT	89.2	118.4	10.0	128.4	Funds added for Motor Nozzle Program and PAM-A for ACTS.
SHUTTLE PROD & OPS CAPABILITY	572.6	469.8	-20.0	449.8	Deleted funds for External Tanks and SRB tooling and development activities, funds added to Filament Wound Case (FWC) to support the Vandenberg Launch Site schedule, transferred Space Shuttle Main Engine test activity to NSTL from MSFC.
STS OPERATIONS	634.4	998.1	-202.0	796.1	Reduced number of flights, savings incorporated from negotiated ET and SRB block buy, FWC deliveries reduced, requested program reserves reduced.
PHYSICS AND ASTRONOMY	334.3	330.4	-47.1	283.3	Reduction of proposed augmentations to Hubble Space Telescope Operations and maintenance, refurbishment, and Space Plasma Lab instruments. Deletion of Gravity Probe-B technology flight initiative.
PLANETARY EXPLORATION	0.1	0.1	0.0	0.1	
SPACE APPLICATIONS	10.0	31.7	-10.0	21.7	Reduction of proposed augmentation of Material Processing activities.
TECHNOLOGY UTILIZATION	0.3	0.4	0.0	0.4	
AERONAUTICAL RESEARCH & TECHNOLOGY	1.0	1.0	0.0	1.0	
SPACE RESEARCH AND TECHNOLOGY	14.0	22.7	-2.5	20.2	Reduction of proposed augmentation for Orbital Transfer Vehicle technology.
COMMERCIAL USE OF SPACE	(1.9)	14.0	-7.8	6.2	Reduction of funds for proposed activities.
SPACE & NETWORK COMMUNICATION & DATA SYS	17.4	35.0	-7.1	27.9	Reduced funding for program support communications.
TOTAL	1716.2	2075.0	-294.5	1780.5	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 BUDGET REQUEST
RESEARCH AND DEVELOPMENT/SPACE FLIGHT, CONTROL AND DATA COMMUNICATION

KENNEDY SPACE CENTER
(Millions of Dollars)

	FY 1985 CURRENT ESTIMATE	FY 1986 CENTER REQUEST	△	FY 1986 BUDGET REQUEST	REMARKS
SPACE STATION	2.8	23.3	-18.0	5.3	Deleted funding for proposed systems engineering tasks.
STS CAPABILITY DEVELOPMENT	34.7	66.9	-10.0	56.9	Deleted funding for proposed engineering and technical base augmentations, reduced funding for Spacelab effort, deleted funding for OMV tasks already included in budget.
SHUTTLE PROD & OPS CAPABILITY	103.2	78.7	-22.0	56.7	Deleted funding for logistics equipment already included in budget, reduced funding for spares.
STS OPERATIONS	269.7	324.8	-6.0	318.8	Reduced funding based on reduced number of flights.
PHYSICS AND ASTRONOMY	6.7	7.2	0.0	7.2	
LIFE SCIENCES	2.1	2.1	0.0	2.1	
TECHNOLOGY UTILIZATION	0.3	0.2	0.0	0.2	
SPACE RESEARCH AND TECHNOLOGY	0.4	0.6	0.0	0.6	
COMMERCIAL USE OF SPACE	(0.3)	5.6	-4.1	1.5	Reduced funding for proposed activities.
TOTAL	419.9	509.4	-60.1	449.3	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 BUDGET REQUEST
RESEARCH AND DEVELOPMENT/SPACE FLIGHT, CONTROL AND DATA COMMUNICATION

NATIONAL SPACE TECHNOLOGY LABORATORIES
(Millions of Dollars)

	FY 1985 CURRENT ESTIMATE	FY 1986 CENTER REQUEST	△	FY 1986 BUDGET REQUEST	REMARKS
SPACE STATION	0.3	0.3	0.1	0.4	
STS CAPABILITY DEVELOPMENT	8.2	7.1	0.0	7.1	
SHUTTLE PROD & OPS CAPABILITY	6.3	1.2	6.0	7.2	Transfer of funding for support to Main Engine testing program previously funded by Marshall.
LIFE SCIENCES	0.1	0.1	0.0	0.1	
SPACE APPLICATIONS	2.7	3.3	0.0	3.3	
TECHNOLOGY UTILIZATION	0.2	0.1	0.0	0.1	
COMMERCIAL USE OF SPACE	(0.2)	1.9	-1.5	0.4	Reduction of funds for proposed activities.
TOTAL	17.8	14.0	4.6	18.6	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 BUDGET REQUEST
RESEARCH AND DEVELOPMENT/SPACE FLIGHT, CONTROL AND DATA COMMUNICATION

GODDARD SPACE FLIGHT CENTER
(Millions of Dollars)

	FY 1985 CURRENT ESTIMATE	FY 1986 CENTER REQUEST	△	FY 1986 BUDGET REQUEST	REMARKS
SPACE STATION	16.2	25.4	-7.6	17.8	Deleted proposed advanced development activities.
STS CAPABILITY DEVELOPMENT	0.3	—	0.0	—	
STS OPERATIONS	0.9	1.1	0.0	1.1	
PHYSICS AND ASTRONOMY	191.1	222.0	-5.0	217.0	Reduced funds for Solar Optical Telescope (SOT) development.
LIFE SCIENCES	0.3	0.2	0.0	0.2	
PLANETARY EXPLORATION	5.1	3.6	0.0	3.6	
SPACE APPLICATIONS	173.1	266.4	-8.0	258.4	Reduced funds for UARS; project reserves rephased.
TECHNOLOGY UTILIZATION	1.0	1.1	0.0	1.1	
AERONAUTICAL RESEARCH & TECHNOLOGY	0.3	0.3	0.0	0.3	
SPACE RESEARCH AND TECHNOLOGY	6.2	6.6	0.0	6.6	
COMMERCIAL USE OF SPACE	(0.2)	4.7	-3.9	0.8	Reduced funding for proposed activities.
SPACE & NETWORK COMMUNICATION & DATA SYS	431.9	377.3	-7.2	370.1	Reduced funding for communications and data systems and advanced systems.
TOTAL	826.4	908.7	-31.7	877.0	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 BUDGET REQUEST
RESEARCH AND DEVELOPMENT/SPACE FLIGHT, CONTROL AND DATA COMMUNICATION

JET PROPULSION LABORATORY
(Millions of Dollars)

	FY 1985 CURRENT ESTIMATE	FY 1986 CENTER REQUEST	△	FY 1986 BUDGET REQUEST	REMARKS
SPACE STATION	4.8	16.6	-9.0	7.6	Reduced funding for advanced development.
STS CAPABILITY DEVELOPMENT	0.3	1.0	0.0	1.0	
SHUTTLE PROD & OPS CAPABILITY	2.3	—	0.0	—	
PHYSICS AND ASTRONOMY	26.7	34.5	0.0	34.5	
LIFE SCIENCES	0.5	1.5	0.0	1.5	
PLANETARY EXPLORATION	215.8	289.8	-5.0	284.8	Deleted proposed augmentation of Galileo reserves.
SPACE APPLICATIONS	66.8	132.4	-29.0	103.4	Rephased reserves for Scatterometer, reduction of proposed augmentation of materials, processing activities, and deletion of TOPEX new initiative.
TECHNOLOGY UTILIZATION	0.1	0.5	0.0	0.5	
AERONAUTICAL RESEARCH & TECHNOLOGY	0.2	0.2	0.0	0.2	
SPACE RESEARCH AND TECHNOLOGY	22.7	27.4	-4.0	23.4	Deletion of proposed augmentation.
COMMERICAL USE OF SPACE	(0.3)	6.0	-5.3	0.7	Reduced funding for proposed activities.
SPACE & NETWORK COMMUNICATION & DATA SYS	117.2	131.8	4.1	135.9	Funding added for data transmission, mission control and data processing support.
TOTAL	457.4	641.7	-48.2	593.5	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 BUDGET REQUEST
RESEARCH AND DEVELOPMENT/SPACE FLIGHT, CONTROL AND DATA COMMUNICATION

AMES RESEARCH CENTER
(Millions of Dollars)

	FY 1985 CURRENT ESTIMATE	FY 1986 CENTER REQUEST	△	FY 1986 BUDGET REQUEST	REMARKS
SPACE STATION	3.7	7.0	-2.5	4.5	Deleted advanced development effort.
STS OPERATIONS	2.6	4.1	-1.0	3.1	Reduced estimate for contingency landing site requirements.
PHYSICS AND ASTRONOMY	57.8	27.5	0.0	27.5	
LIFE SCIENCES	24.3	28.8	0.0	28.8	
PLANETARY EXPLORATION	16.8	10.2	0.0	10.2	
SPACE APPLICATIONS	4.2	4.7	0.0	4.7	
TECHNOLOGY UTILIZATION	0.1	2.0	0.0	2.0	
AERONAUTICAL RESEARCH & TECHNOLOGY	132.4	158.8	-12.6	146.2	Reduction in R&T base funding request for proposed studies in computational fluid dynamics, rotorcraft systems and technology.
SPACE RESEARCH AND TECHNOLOGY	14.8	15.7	-0.4	15.3	Reduction in R&T base funding request.
COMMERCIAL USE OF SPACE	(0.3)	1.9	-1.0	0.9	Reduction in funds for proposed activities.
SPACE & NETWORK COMMUNICATION & DATA SYS	8.6	10.9	0.1	11.0	Minor adjustment to estimate.
TOTAL	265.3	271.6	-17.4	254.2	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 BUDGET REQUEST
RESEARCH AND DEVELOPMENT/SPACE FLIGHT, CONTROL AND DATA COMMUNICATION

LANGLEY RESEARCH CENTER
(Millions of Dollars)

	FY 1985 CURRENT ESTIMATE	FY 1986 CENTER REQUEST	△	FY 1986 BUDGET REQUEST	REMARKS
SPACE STATION	4.2	14.9	-10.8	4.1	Reduced tasks not applicable to station Initial Operational Capability.
STS CAPABILITY DEVELOPMENT	0.3	—	0.2	0.2	Estimate adjusted to be consistent with FY85 operating plan.
STS OPERATIONS	0.1	—	0.1	0.1	Estimate adjusted to be consistent with FY85 operating plan.
PHYSICS AND ASTRONOMY	2.9	3.2	0.0	3.2	
LIFE SCIENCES	0.5	0.6	0.0	0.6	
SPACE APPLICATIONS	12.0	11.7	0.0	11.7	
TECHNOLOGY UTILIZATION	0.5	0.5	0.0	0.5	
AERONAUTICAL RESEARCH & TECHNOLOGY	115.3	140.9	-39.6	101.3	Reduction in R&T base funding request, termination of advanced composite structures technology program, deleted proposed augmentation in quiet rotorcraft systems and advanced configurations research.
SPACE RESEARCH AND TECHNOLOGY	38.3	51.3	-6.3	45.0	Reduced funding for augmentation in control of flexible structures, reduced requested funding for R&T base.
COMMERCIAL USE OF SPACE	(1.0)	2.9	0.7	3.6	Increased funding for additional activities.
TOTAL	174.1	226.0	-55.7	170.3	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 BUDGET REQUEST
RESEARCH AND DEVELOPMENT/SPACE FLIGHT, CONTROL AND DATA COMMUNICATION

LEWIS RESEARCH CENTER
(Millions of Dollars)

	FY 1985 CURRENT ESTIMATE	FY 1986 CENTER REQUEST	△	FY 1986 BUDGET REQUEST	REMARKS
SPACE STATION	16.8	44.3	-17.5	26.8	Deleted funding for advanced development tasks for various power options not applicable to station Initial Operational Capability.
STS CAPABILITY DEVELOPMENT	73.0	127.0	-11.7	115.3	Deleted funds for Centaur advanced electronics effort, reduced reserves for Centaur production vehicles, funding added for upper stage for TDRS-6.
SPACE APPLICATIONS	55.5	37.9	63.0	100.9	Addition of funds for ACTS, reduced funds for proposed augmentations to materials processing research.
TECHNOLOGY UTILIZATION	0.4	0.3	0.0	0.3	
AERONAUTICAL RESEARCH & TECHNOLOGY	86.0	111.4	-13.6	97.8	Funding reduced for R&T base, and hot engine technology program, funding deleted for proposed augmentation in turbine and convertible engine research.
SPACE RESEARCH AND TECHNOLOGY	34.4	48.4	-10.6	37.8	Funding reduced for proposed OTV technology augmentation, and R&T base funding; deleted for proposed spacecraft propulsion and power augmentation.
COMMERCIAL USE OF SPACE	(0.7)	9.5	-7.5	2.0	Funding reduced for proposed activities.
TOTAL	266.1	378.8	2.1	380.9	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 BUDGET REQUEST
RESEARCH AND DEVELOPMENT/SPACE FLIGHT, CONTROL AND DATA COMMUNICATION

HEADQUARTERS
(Millions of Dollars)

	FY 1985 CURRENT ESTIMATE	FY 1986 CENTER REQUEST	△	FY 1986 BUDGET REQUEST	REMARKS
SPACE STATION	4.0	8.5	-2.3	6.2	Reduced funding for utilization and systems engineering.
STS CAPABILITY DEVELOPMENT	32.2	20.3	15.0	35.3	Flight demo and satellite services funding not yet allocated to Centers.
SHUTTLE PROD & OPS CAPABILITY	66.3	91.4	0.0	91.4	
STS OPERATIONS	23.4	67.2	0.0	67.2	
PHYSICS AND ASTRONOMY	49.0	48.1	0.0	48.1	
LIFE SCIENCES	12.5	12.1	0.0	12.1	
PLANETARY EXPLORATION	42.9	49.3	0.0	49.3	
SPACE APPLICATIONS	38.0	43.7	0.0	43.7	
TECHNOLOGY UTILIZATION	6.4	5.7	0.0	5.7	
COMMERCIAL USE OF SPACE	(2.6)	12.3	0.0	12.3	
AERONAUTICAL RESEARCH & TECHNOLOGY	6.2	6.2	0.0	6.2	
SPACE RESEARCH AND TECHNOLOGY	7.5	7.5	0.0	7.5	
SPACE & NETWORK COMMUNICATION & DATA SYS	235.2	309.6	-30.0	279.6	Reduction in FFB prepayment on TDRSS loan.
NATIONAL SECURITY LAUNCH ASSURANCE	—	50.0	-50.0	—	Deletion of funds for proposed activity.
TOTAL	523.6	731.9	-67.3	664.6	

QUESTION 3:

Please furnish by major line item, the NASA operating plan for FY 1984 and FY 1985 with comments on adjustments, if any.

ANSWER 3:

See Table C attached.

TABLE C

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1984 AND FY 1985 OPERATING PLANS
BY BUDGET LINE ITEMS

(Dollars in Millions)

	FY 1984	FY 1985
RESEARCH AND DEVELOPMENT	2064.2	2422.6
Space Station	(21.9) a/	150.0 b/
Space Transportation Cap. Dev.	431.7	351.4
Physics and Astronomy	567.6	677.2
Life Sciences	58.0	62.3
Planetary Exploration	217.4	290.9
Space Applications	314.0	374.1
Technology Utilization	9.0	9.5
Commercial Use of Space	0.0	(8.5) c/
Aeronautical Research and Technology	315.3	342.4
Space Research and Technology	137.0	150.0
Tracking and Data Advanced Systems	14.2	14.8
SPACE FLIGHT CONTROL AND DATA COMMUNICATIONS	3772.3	3601.8
Shuttle Prod. and Operational Capability	1646.3	1492.1
Space Transportation Operations	1452.0	1314.0
Space and Ground Network, Comm. and Data Sys.	674.0	795.7
RESEARCH AND PROGRAM MANAGEMENT	1255.9	1336.3 d/
CONSTRUCTION OF FACILITIES	155.5	150.0
TOTAL NASA	7247.9	7510.7

NOTE: The FY 1985 amounts are consistent with the Operating Plan transmitted to the Committees on 10/3/84, except for Research and Program Management.

a/ In FY 1984, funded as part of the Office of Space Flight ($13.0M), Office of Aeronautics and Space Technology ($6.0M), Office of Space Science and Applications ($2.0M), and Office of Space Tracking and Data Systems ($0.9M).

b/ In addition, $5.5M will be made available from FY 1984 aporopriations for Space Station definition studies in FY 1985.

c/ In FY 1985, funded as part of the Office of Space Station ($0.2M), Office Space Flight ($4.5M), Office of Space Science and Applications ($2.0M), Office of Aeronautics and Space Technology ($0.7M), and Office of Space Tracking and Data Systems ($1.1M).

d/ Includes $23.3 for a proposed pay raise supplemental offset by a proposed rescission pursuant to the Deficit Reduction Act of 1984.

QUESTION 4:

Please provide a tabulation of projected total costs of all major programs including (please include initial estimates for budgeted new starts):

a. original estimate date and amount,
b. current estimate, and
c. NASA's estimate of what portion of any increased cost may be due to inflation.

ANSWER 4:

See Table D attached.

Table D

National Aeronautics and Space Administration
Estimated Total Project Cost
(In Millions of Dollars)

	Original Development Estimate		Current Estimate
	Date	Range	Range
Hubble Space Telescope Development	2/78	565-611 (a)	1175 (a)
Ulysses Development	1/83	120-140	120-140
Ulysses Mission Ops. & Data Analysis	1/83	20-30	20-30
Gamma Ray Observatory (GRO) Development	1/83	395-435	395-435
GRO Mission Ops. & Data Analysis	1/83	30-40	30-40
Galileo Development	1/83	650-700	650-700
Galileo Ops. & Data Analysis	1/83	180-210	180-210*
Venus Radar Mapper (VRM) Mission Development	1/83 (b)	320-350 (b)	320-350 (b)
VRM Mission Ops. & Data Analysis		30-50 (b)	30-50 (b)
Earth Radiation Budget Experiment (ERBE)	1/83	110-130	110-130
Advanced Communications Technology Satellite (ACTS) project	1/83 (b)	325-425 (b)	325-425 (b)
Tethered Satellite	1/83 (b)	40-50 (b)	50-60 (c)
Upper Atmosphere Research Satellite (UARS)	1/84 (b)	630-700 (b)	630-700 (b)
Mars Observer	1/84 (b)	300-375 (b)	300-375 (b)
Scatterometer	1/84 (b)	120-135 (b)	120-135 (b)
Orbital Maneuvering Vehicle	1/85 (b)	375-450 (b)	375-450 (b)

* Galileo Operations and Data Analysis runout is under review as a result of the addition of an option to fly by asteroid Amphritrite prior to the Jupiter encounter. It is estimated that the increase will be on the order of $20-25 million.

(a) Original Space Telescope estimate, which supported a late 1983 launch, was stated in FY 1978 budget dollars, to be updated annually; this estimate has been updated to reflect real year dollars. The increase reflected by the current estimate is due to continuing development problems and a series of launch slips from late 1983 to the second half of 1986.

(b) Planning estimate; development estimate not yet available.

(c) This estimate has been increased due to better definition of the technical requirements.

QUESTION 5:

Please furnish, by major program, the unobligated balance of funds for FY 1984 and FY 1985 and the actual or estimated carry over as of January 15, 1985.

ANSWER 5:

See Table E attached.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
UNOBLIGATED BALANCE
(Millions of Dollars)

Table E

	FY 1984 & PRIOR UNOBLIGATED BALANCE 9/30/84	FY 1985 UNOBLIGATED BALANCE AS OF 12/31/84	ESTIMATED UNOBLIGATED BALANCE 9/30/85
Research and Development			
Space Station	--	137.2	7.5
Space Transportation Capability Dev.	123.1	300.1	17.6
Physics and Astronomy	57.1	456.1	33.9
Life Sciences	5.0	45.0	3.1
Planetary Exploration	26.5	202.9	14.5
Space Applications	76.7	321.6	18.7
Technology Utilization	3.3	8.9	0.5
Aeronautical Research and Technology	26.8	233.7	17.1
Space Research and Technology	14.8	107.2	7.5
Tracking and Data Advanced Systems	2.4	12.2	0.7
TOTAL RESEARCH AND DEVELOPMENT	335.7	1824.9	121.1
Space Flight, Control and Data Communications			
Shuttle Production and Operational Capability	77.0	1001.4	74.6
Space Transportation Operations	54.3	810.8	65.7
Space and Ground Network Communications and Data Systems	83.4	463.1	39.7
TOTAL SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	214.7	2275.3	180.0
CONSTRUCTION OF FACILITIES	122.9	146.3	86.7
RESEARCH AND PROGRAM MANAGEMENT	--	982.2 a/	--
TOTAL NASA	673.3	5228.7	387.8

All Research and Program Management funds are planned for obligation by the end of FY 1985. A small portion of the R&D and SFCDC will remain unobligated in the procurement pipeline at the end of the fiscal year. This amount, statistically equivalent to a few weeks of procurement activity, will be obligated in the next fiscal year. These amounts in the procurement pipeline have no impact on the following fiscal year requirements. For Construction of Facilities, it is estimated that $112.5 million of the FY 1985 appropriation of $150.0 million will be obligated in FY 1985, leaving an unobligated balance of $37.5 million. In addition, $51.2 million of prior appropriations are estimated to be unobligated at the end of the year.

a/ Includes $23.3 proposed supplemental to cover revised salary rates effective January 1985 and $4M proposed rescission.

QUESTION 6:

Please provide a summary of the Space Shuttle production sub-line item by major program element and by production orbiter vehicle including initial cost estimates, current cost estimates, all changes which have occurred, and associated schedule changes.

ANSWER 6:

At the time of the Shuttle development commitment, the requirements to establish an operational Orbiter fleet were projected at $1 billion in 1971 dollars. This estimate was to provide for the modification or refurbishment of two Orbiters (Orbiter 101 and 102) bought in the development phase and the procurement of three additional Orbiters.

Since that original estimate, planning for the implementation of the Orbiter fleet has been impacted by factors such as budget reductions, Orbiter delivery schedule adjustments, revised estimates based on experience in the development phase, and new requirements identified during the development test flight program. These include the FY 1977 budget decision to defer the start of the production; schedule adjustments related to the Agency's realignment of program funding between design, development, test and evaluation and production in FY 1978 and FY 1979; the FY 1979 budget decision to delay proceeding with a fifth Orbiter; the actual Orbiter and main engine fabrication and assembly experience on development hardware; the delivery schedule stretch-out included in the FY 1980 and FY 1981 budget plans; and the identification of new requirements, such as the orbiter weight reduction program and systems engineering support. Based on the combined effects of these varied impacts, the current estimate to establish the fleet of operational Orbiters is $3.5 billion in dollars of the FY 1986 budget which is equivalent to $1.6 billion in FY 1971 dollars. This estimate provided for modifying Orbiter 102 for the first Spacelab mission in FY 1983 and subsequently full operational modifications including structural changes to be completed during FY 1985, upgrading the Orbiter structural test article to an Orbital configuration (Orbiter 099), and the fabrication and assembly of two additional Orbiters and associated main engines. Three orbiters have now been produced and the fourth Orbiter is in final assembly.

A comparison of the original and current production Orbiter delivery schedules is as follows:

	Orbiter Deliveries	
Plan	Original Plan (03/72)	Current
Orbiter 101 Modified	March 1979	--
Orbiter 099 (STA Modified)	--	July 1982 (Actual)
Orbiter 102 (Spacelab Mod)	--	July 1983 (Actual)
Orbiter 103	December 1978	Oct 1983 (Actual)
Orbiter 104	October 1979	April 1985
Orbiter 105	August 1980	--
Orbiter 102 Full Mod	December 1980	FY 1985

In addition to fleet investment, the current Shuttle Production and Capability Development budget planning also includes orbiter and second-line facility ground support equipment at KSC required for a capability to process more than one vehicle concurrently; system integration and support activities; the procurement of an initial inventory of operational spares and crew equipment; the procurement of SRB and ET rate tooling to meet the projected 24 per year flight rate capability; the provision for modifications to incorporate Centaur within the Shuttle vehicle, the development of a Filament Wound Case for the Solid Rocket Booster to augment performance changes, systems upgrades and provide for potential changes or systems modifications required from flight experience to increase reliability and safety and to lower STS operating costs.

QUESTION 7:

Please provide a requirements and production cost analysis for a Fifth Orbiter based on initiating the production buy in Fiscal Year 1986 compared with Fiscal Year 1987 and Fiscal Year 1988 including the implication of the loss of an Orbiter, the implications of an Orbiter being out of service for an extended period, and the implications regarding maintenance of the subcontractor base.

ANSWER 7:

The need for a Fifth Orbiter has been studied over the past several years, including an intensive review for the FY 1984 budget submittal to Congress. These studies, conducted by both internal and external groups, have reached the same basic conclusion that the currently authorized four Orbiter fleet can support the projected launch requirements at least through the end of this decade.

A complete review of the sensitivities and cost as related to an enlarged STS Orbiter fleet has been provided to Congress on February 1, 1984. The capability to produce additional Orbiters has been retained by the implementation and augmentation of the structural spares program.

This program, which continues through FY 1987, will provide major structural elements that could be used to repair one of the four Orbiters or to initiate production of a fifth orbiter of a fifth orbiter.

Cost for procurement of a Fifth Orbiter, including the $460 million structural spares program is estimated as follows:

FY 1986 start - June 1990 delivery: $2.2 billion
FY 1987 start - June 1991 delivery: $2.4 billion
FY 1988 start - June 1992 delivery: $2.6 billion

QUESTION 8:

Please provide a summary of the Space Shuttle operational capabilities that were originally proposed at the beginning of the program as compared to the operational capabilities which currently exist. This summary should include but not be limited to payload launch capability (ETR and WTR), flight rate capability, on-orbit stay time, cost per flight, and orbiter turnaround time. This summary should also include a schedule for planned performance improvements.

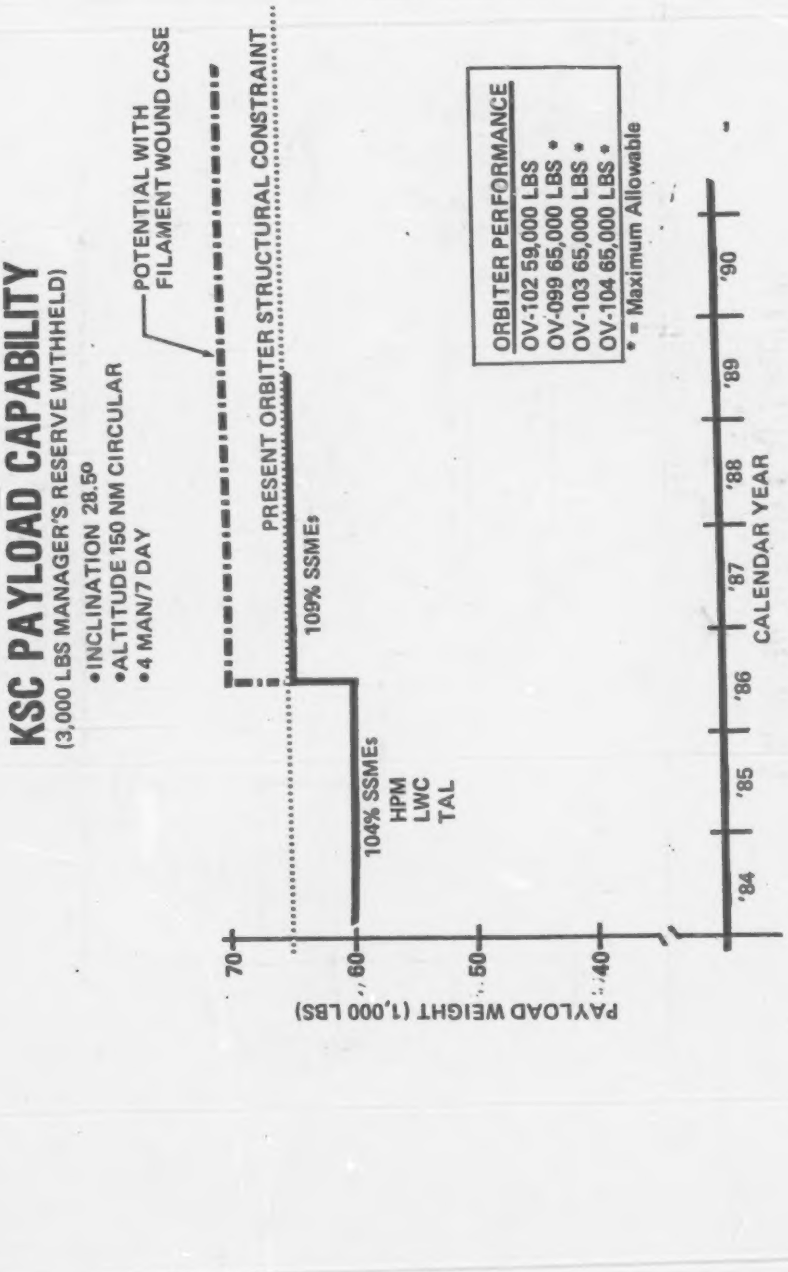
ANSWER 8:

Item		Originally Proposed	Current Capability
Payload Launch Capability			
	ETR	65,000 lbs.	65,000 lbs.
(Max)	WTR	32,000 lbs.	32,000 lbs.
Flight Rate		60 per year	24 per year
On-Orbit Stay Time (Max)		Up to 30 days with expendables	10 days
Cost-per-Flight ($82)		$34.5 million*	$83.3 million*
Orbiter Turnaround Time		160 hours over	35 days
Max Orbit		600 nautical miles	400 nautical miles
Launch Inclination	ETR	28.5o - 57o	28.5o - 57o
	WTR	56o - 104o	56o - 104o
On Orbit Repair		Yes	Yes
Intact Abort		Yes	Yes
Down Cargo		32,000 lbs.	32,000 lbs.
Airfield Landing Char		15,000 feet long	15,000 feet long
Crew	Nominal	4	5
	Max	10	10
SRB Reuse		20	20
Standby Launch			
	Standby Status	24 hours	24 hours
	Launch	2 hours	4 hours

* Based on $18 million 75$ for 572 flights over 12 years with a sustained flight rate of 4- per year
** Operating cost estimate for a flight in the 1989-91 timeframe based on a sustained flight rate of 24 per year

The attached figures 1 and 2 show the schedule for achieving payload performance capability at the Kennedy Space Center (KSC) and at the Vandenberg Air Force Base (VAFB), respectively.

Figure 1


KSC PAYLOAD CAPABILITY
(3,000 LBS MANAGER'S RESERVE WITHHELD)
•INCLINATION 28.5º
•ALTITUDE 150 NM CIRCULAR
•4 MAN/7 DAY
POTENTIAL WITH FILAMENT WOUND CASE
PRESENT ORBITER STRUCTURAL CONSTRAINT
109% SSMEs
104% SSMEs
HPM
LWC
TAL
ORBITER PERFORMANCE
OV-102 59,000 LBS
OV-099 65,000 LBS *
OV-103 65,000 LBS *
OV-104 65,000 LBS *
* = Maximum Allowable
PAYLOAD WEIGHT (1,000 LBS)
70
60
50
40
'84
'85
'86
'87
'88
'89
'90
CALENDAR YEAR

VAFB PAYLOAD CAPABILITY

(3,000 LBS MANAGER'S RESERVE WITHHELD)

INCLINATION - 98°
ALTITUDE - 150 N M CIRCULAR

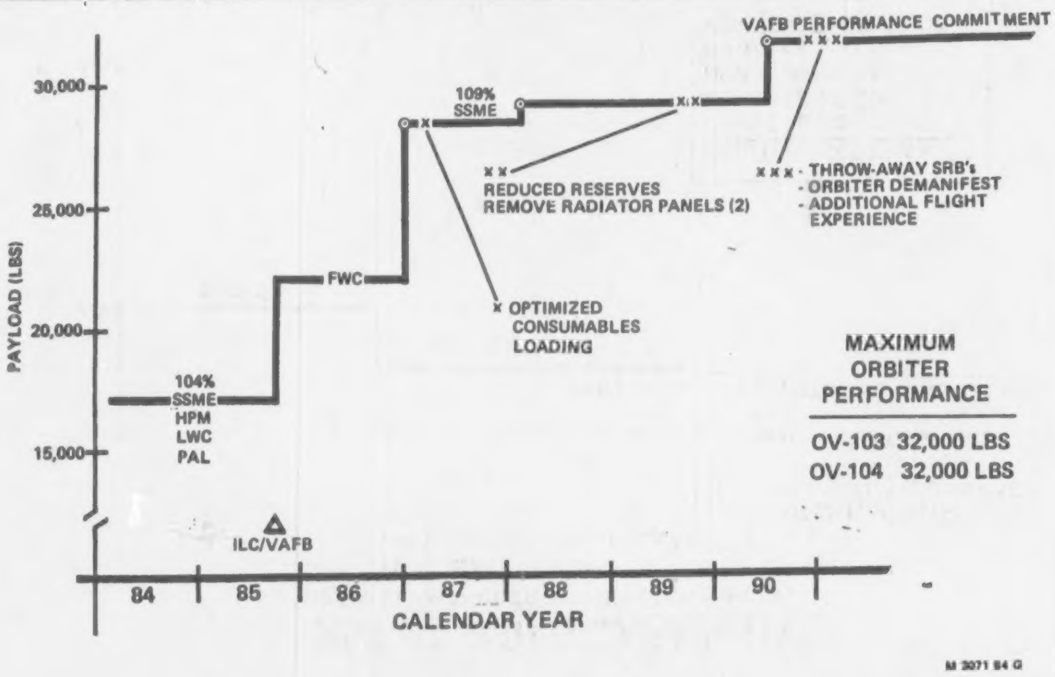


Figure 2

QUESTION 9:

Please provide an analysis of the effect of inflation on the aggregate buying power of NASA. Please include separate summary of the Space Shuttle program cost estimates and the effect of inflation on total cost at completion estimates.

ANSWER 9:

See Tables F attached. It should be noted that the DDT&E for Shuttle ended in FY 1983.

2/7/85

Table F

National Aeronautics and Space Administration

EFFECT OF INFLATION ON NASA BUDGET
COMPARATIVE PURCHASING POWER INDICES FY 1973 - 1986

	GNP Price 1/ Deflator (%)	NASA Aerospace 2/ Price Deflator (%)	Budget Outlays - Millions of Dollars Actuals	Constant FY 1973 3/	Constant FY 1973 4/
FY 1973	100.0	100.0	3315	3315	3315
FY 1974	91.9	93.3	3256	3038	2992
FY 1975	84.1	84.2	3267	2751	2748
FY 1976	79.9	77.2	3669	2832	2932
FY 1977	75.6	69.7	3945	2750	2982
FY 1978	70.3	64.7	3983	2577	2800
FY 1979	64.8	59.1	4197	2480	2720
FY 1980	59.3	53.4	4850	2590	2876
FY 1981	54.1	48.2	5426	2615	2935
FY 1982	51.0	44.0	6035	2655	3078
FY 1983	49.2	41.5	6664	2766	3279
FY 1984	47.4	39.2	7048	2763	3341
FY 1985 5/	45.7	37.0	7317	2707	3344
FY 1986 5/	43.8	34.8	7772	2704	3404

1/ Economic Indicators, December 1984, year over year growth.
2/ Reflects labor intensive nature of NASA purchases using aerospace related inflation data.
3/ Constant FY 1973 outlays calculated using the NASA Aerospace Price Deflator.
4/ Constant FY 1973 outlays calculated using the GNP Price Deflator.
5/ Current estimates.

TABLE F

National Aeronautics and Space Administration

EFFECT OF INFLATION ON SHUTTLE DEVELOPMENT COSTS

(millions of dollars)

	Baseline Estimate FY 1971 Dollars	Current Estimate FY 1971 Dollars	Current Estimate Inflated Dollars	Impact of Inflation on Current Estimate
Design, Development, Test & Evaluation (DDT&E)	$5,150	$6,745	$10,078	$3,333

QUESTION 10:

In accordance with Rule IX, Clause 2(1) (4) of the Rules of th House of Representatives, the Committee is required to include in the report accompanying the NASA authorization bill an assessment of the impact of the legislation on inflation. Please provide the Committee with any information or reports which would be useful to the Committee in fulfilling this requirement.

ANSWER 10:

In accordance with Rule XI, Clause 2(1) of the Rules of the House of Representatives this legislation is assessed to have no adverse long-run inflationary effects on prices and cost in the operation of the national economy. NASA expenditures are labor intensive, with approximately 80 percent of spending directly for jobs and the remainder for materials. NASA employs about 21,800 civil servants and supports about 133 thousand contractor and support services employees. Assuming multiplier effect 2.5, the total, short-run employment effect on the United States' economy is about 390 thousand jobs. This represents less than one-half of one percent of the total civilian labor force in the United States--too small to have a significant national effect. There could however be some specific cases of industrial and regional employment and price changes influenced by NASA expenditures.

One of the most significant economic effects of NASA spending is the long-run productivity advance from new technologies developed for the space and aeronautics programs. Many NASA-sponsored advances in air and space transportation, communications satellites, remote sensing satellites, and other innovations have improved the productive capacity of industry and stimulated the development and growth of many new businesses.

NASA is actively pursuing its role to expand the opportunities for private industry to gain access into space effectively and economically use space for commercial ventures. These expanded business opportunities have stimulated and are expected to continue to stimulate more productive, non-inflationary private sector economic growth, job creation and improve the United States competitive economic position in the world, e.g., improve United States trade balance.

The CHAIRMAN. Thank you very much, Jim, and I am sure you are familiar with the recent OTA study that came out in the fall, relating to the space station, and there are several conclusions that they arrived at, and I would like to get your thoughts on those.

One was that they said there was no compelling reason to build the NASA baseline design, and said there were less costly designs, and different management options should be reviewed.

They also indicated that specific design and cost options could not be chosen until long-range civil space goals have been set. Would you comment on that, and give your response to that report?

Mr. BEGGS. Mr. Chairman, I read that report from cover to cover. And, actually, if you read the report in its entirety, you will find that it is, as I am sure you have, you will find that it is generally favorable to the development of space stations and speaks of many future missions.

The CHAIRMAN. It gives a good definition of what $2 billion is. Most people can understand.

Mr. BEGGS. There were a number of conclusions drawn in the report which generally sustain and support the program that we have conducted for 26 years and indeed, speak very favorably about a number of options in the future. It does, however, make the points that you just illustrated with respect to our need to further develop our concept and look at other concepts. And, my response to that is that is precisely what we are setting about doing in the phase B studies.

We configure this program with a very, very long—long in the sense of what we have conducted in the past, when initiated a major program and comprehensive phase B concept development effort that will run for better than 2 years, and during that period. We will, and have, drawn the RFP to the industry partners that will join us in these studies in such a way that we will consider a number of different options, including the one I referred to in my remarks; that is, more automation, and greater use of robotics and other labor-saving kinds of facilities.

So, my general response to that critique in the OTA report is precisely what we are setting out to do. We, of course, can always argue as to whether we are considering all of the options that various and sundry would have us consider, but we are going to consider a very broad range of those options.

With respect to the other comment that we ought to be laying down a long-range goal, or a long-range series of objectives, I think that is fully covered by the Commission that the Congress created this past year.

There will be a commission, which I am led to believe will be announced very shortly, which will——

The CHAIRMAN. Did you say the membership will be appointed shortly?

Mr. BEGGS. I believe so, Mr. Chairman.

The CHAIRMAN. That would be helpful for it to get moving.

Mr. BEGGS. Yes, sir, I understand that, and I have emphasized that to some of the staff in the White House, that it is timely to get on with it. I believe it will be done shortly, but that Commission is empowered, as you know, to look fully at future objectives and options for the Nation in space. And, I believe that they will do that in a very positive and forthright fashion. NASA, of course, will have a staff role in that study, and I myself will be a part of the considerations of that Commission.

We will indeed lay down long-term objectives, and it is this President's desire that we set long-term objectives. In his policy announcements and the issuance of the national space policy, he specifically calls for a continuation into the distant future of space activities, so I think we are addressing the issues that the OTA was concerned with in their report. We may not be doing it in quite the time sequence that we would like, but I would urge that we not get tangled up, or that we not confuse long-term planning with our current program priorities, because the program does need to continue moving and we have, in the last 26 years, initiated programs which we felt were quite well-considered in terms of the long-term future of our space exploration, and the continuation of that with the space station is well-advised while we decide what our long-term objectives will be.

The CHAIRMAN. What is the status of the international participation? You talked about ESA and their recent meeting in Rome. How about the Canadians and Japan?

Mr. BEGGS. The Japanese are, if anything, moving more with a greater degree of acceleration into the program than the Europeans. They have a number of engineers hard at work trying to define the various things that they would like to do. The indication is that they, too, will join in the phase B study effort. Indeed, they have made a proposition to do that in their budget for the coming year.

The Canadians are lagging a little bit behind both the Europeans and the Japanese. They are struggling with a budget crunch of their own, and have indicated that they are still very much interested in joining, but they might be a little bit slower in coming into the phase B efforts than either the Europeans or the Japanese.

I don't want to be too negative on that, Mr. Chairman. My conclusion is that they will join us.

The CHAIRMAN. Two follow-up questions.

One, are you running into a problem of technology transfer that is going to have an impediment on the international participation?

Second, you asked for $285 million this year. It was cut to $230 million. What impact will that slip have on international participation?

Mr. BEGGS. The technology transfer issue is one that is going to be with us, I think, throughout this program, not only from our side, but from their side.

When I made my initial contacts with the Europeans, the Japanese, and the Canadians over a year ago, they all emphasized the importance of protection of intellectual property rights in this program.

The CHAIRMAN. Does that include current or discovered information?

Mr. BEGGS. They were mostly worried about discovery, but they were also somewhat concerned about a reverse transfer of current technology which might occur as a consequence of their participation with us and participation with our industry.

They emphasized that—before I raised the issue, they raised the issue, so they are concerned about it, and we are, too. We have become quite concerned about the competitive aspects of technology transfer across international borders which results in commercial advantage for someone, from someone else's investment.

And so, it is an issue that we are going to have to keep right at the top of the agenda, but both the Europeans, the Japanese, the Canadians and ourselves all agree that we felt we could put sufficient protections in our agreements, and that we could draw the interface lines cleanly enough, that we could, given a willingness to work together, and we have always been able to do that in the past, that we could prevent any kinds of serious disadvantages occurring to any of the partners, and I believe that.

As you know, we have had literally upward of 1,000 international agreements in our Space Program over the past quarter-century, and while it is true that we have sometimes given the technology, we have offered it either gratuitously or have offered it at a price in those agreements.

When we wanted to protect our technology, we have always been able to do it. The plain facts are that the technology that some folks worry about with respect to the Space Program are things that we have given away. The Nation has decided, for what I think were good and sufficient policy reasons that we wanted to advance or help advance the economies of certain countries, so that we have helped them with space technology.

I think that has paid off substantially and it has also, without any question, resulted in some competitive advantage, so what we have done, it seems to me, in a quarter of a century is, it hasn't been a leak. It has been a case of a conscious policy decision to provide space technology to our friends and allies in various parts of the world, but where we have tried to put a fence around it, where we have concluded an agreement, where we have drawn lines and made the interface fairly clean between the partners, I think we have done a fairly good job of protecting the technology that we have developed.

And at the same time, they have protected the technology that they have developed.

The CHAIRMAN. How about the slip in the schedule?

Mr. BEGGS. The slip in the schedule is something that is of concern for several reasons. One would like to move as quickly as you can in a program such as this, because generally speaking, that enables you to do the job for the least amount of resources, but with respect to the partners, friends, allies we have joining us, the slip will mean very little, if anything, to them.

They have been urging on us a little bit slower schedule than we were proposing anyway. At the same time, I think we have a schedule that allows us to continue to maintain the pressure that you need to maintain to ensure that they do move with due diligence and speed to enter the program, so I don't look on it as serious with respect to the international collaboration.

We would like to keep moving as quickly as we can, although the budget this year does mean we will be somewhat slower than we had anticipated last year.

The CHAIRMAN. Mr. Lujan?

Mr. **Lujan**. Thank you, Mr. Chairman.

Mr. Beggs, during December, I guess it was, we had, the committee had the opportunity to visit six or seven of the contractors interested in the phase B studies, and I was very impressed. They were all very complimentary about the capabilities and competence of NASA, the whole thing together, so I think for the record, that ought to be said publicly, because that is a great achievement.

In the release that was put out by the European Space Agency, they spoke of 13 nations, plus Canada, being in on the meeting and the international cooperation area, in that area, do you anticipate that Canada will be part of—maybe I misunderstood the participation—but the European Space Agency will be participating as a group rather than individual countries.

Will Canada be part of that group, or do they intend to do something on their own?

Mr. **Beggs**. No, sir; Canada has an observer status in ESA and has had for a number of years, and they have chosen to participate in a small way in some selected ESA Programs, but they are not included in the general budget activities, general budget framework of ESA. I don't believe that they will choose to participate through ESA in the space station. They will do that independently, when they decide what they are going to do.

We had urged on ESA, however, from the point of view of the member nations, the full member nations of ESA, that they do their collaboration in the ESA framework. There is an obvious advantage for us, if they do that, because it means that we can deal with a single entity, instead of dealing with a number of individual countries.

Mr. **Lujan**. I was interested with like the Italians with the Tether Program, would you look at them participating within ESA or separate?

Mr. **Beggs**. I would envision they will join fully with the Columbus project, which is a series of platforms and other activities within the ESA framework. They will continue to pursue their independence in things like the Tether and some other things, independently of ESA. That has been true as well, our European colleagues sometimes choose to go independently on a program.

We have several independent programs with the Federal Republic of Germany and the IRAS spacecraft was an ex-ESA program between ourselves, the Netherlands and Great Britain, so they do both. The major collaborations which involve contributions of such a large budget such as the Spacelab have been done within the ESA framework, and we would assume the space station will be similarly constituted.

Mr. **Lujan**. You talked about stretching out of the space station. Dr. Keyworth yesterday said it would be 6 months.

Mr. **Beggs**. That is a fair estimate. It may be 6 to 9 months.

Mr. **Lujan**. Any cutting of that $230 million would seriously jeopardize it, if the committee members looked at that 230?

Mr. **Beggs**. If the committee takes cognizance of the fact that, as you know, last year when we submitted the runout on this program we suggested $280 million, so we have taken a $50 million reduction. Any further reduction, we would view as serious difficulty.

Mr. LUJAN. With TDRS, the second one will be going up, the third one, when will it be fully operational?

Mr. BEGGS. We hope by the end of the year.

The second one goes up on this flight this month, and assuming we get that satisfactorily into orbit—you will recall we had trouble with the first one and had to use a substantial percentage of the station keeping fuel in getting it into proper orbit, so it is life, while we were very happy to have it in orbit, and it has been performing very well for us, the latest mission TDRS performed flawlessly, it will be limited in life, so we are going to try to get the third one up by early fall, September time period, and that is still being worked on, Mr. Lujan.

I would hope that you don't hold me too tightly to those dates, because we have several payloads that are in line late this year. We are going to be flying once a month. One is a Defense Department payload which has priority, so we are still working that problem as to which goes first.

Mr. LUJAN. Will that third one be ready to replace that first one?

Mr. BEGGS. Yes; the intent is to use the third one to replace the first one and put the first one into a spare orbit, use it as a spare and later on, we will replace that one, as its life starts to run out with the fourth one.

We should be operational close to the end of the year, or if not the end of the year, my friend Bob Aller back here is probably grimacing, but early in 1986.

The CHAIRMAN. Mr. Glickman.

Mr. GLICKMAN. Mr. Beggs, it is a pleasure to see you here, and I would like to pursue two lines of questioning with you. One that has to do with the Aeronautics Program. I do have some concerns about the Composite Structures Program being terminated.

I also want to encourage you, as Mr. Lewis did, to pursue the hypersonic, transatmospheric, and other high-speed areas vigorously.

We started something this last year, we created a Congressional Advisory Committee on Aeronautics, a group of 20 people from the private sector from engineers to folks high up in the aeronautics and aerospace industry who are reviewing their programs.

They have been extremely diligent, more than any other advisory committee I can think of, in working with Mr. Jack Martin of your office and others, and they may be coming up with some substantial revisions perhaps of the NASA Aeronautics Program.

I have not seen them yet, but I would just hope that NASA would respond with an open mind to an across-the-board ad hoc committee that is looking at everything that you have been doing in your R&D base, systems technology work, and we on this committee intend to pursue it with an open mind.

It is a real grass roots input, and I would encourage you to keep an open mind with respect to the functioning of that Congressional Advisory Committee.

Mr. BEGGS. Yes, sir, we certainly will.

If I may, Mr. Glickman, if I might respond, since the issue of hypersonics has been raised by you and Mr. Lewis, we are getting a lot of data and doing quite a lot of very interesting research work, using the shuttle, when the shuttle reenters, it is a transatmospheric vehicle flying at hypersonic speeds, and we have been instrumented on some of the shuttles to look very carefully at what happens when you reenter the atmopshere at hypersonic speed, so we are getting a lot of very good research data using the shuttle and will continue to do that. And, of course, the option is open for the future. If one wanted to use the shuttle system to drop off, if you will, experimental vehicles to fly into the atmopshere at hypersonic speeds, and we have looked generally at what would be required to do that, so there is, I think, a great opportunity with the shuttle system to further explore the hypersonic speed regime and get a lot of data on what hypersonics are like in the upper atmosphere.

We also, of course, have a relatively modest research budget, using our wind tunnels and other research facilities to examine that speed regime as well.

Mr. Glickman. OK, this is a subject the committee ought to pursue.

The space station, I don't want to be a lead weight on this issue, but I have got to express some serious concerns about the cost of the space station, and let me phrase it in this way:

When you originally started the Shuttle Program, it was estimated to cost about $5 billion, and I realize we have had inflation and other factors, but it has ultimately ended up costing about $14 billion or so.

We have very high deficits. The President's budget does really nothing with respect to getting those deficits down, and I am not sure if Congress is going to be able to come up with a very good response to get those deficits down.

We will try, but you have spoken about an $8 billion ceiling on the space station and also about the station by the yard, implying if costs increase less capability would be procured.

I would like it for scientific purposes, but I think that we have to be honest about the cost of this station, and I think it is going to cost a heck of a lot more than $8 billion. That is going to be a floor, not a ceiling, and if the history of the shuttle and the history of defense systems are any guide to the costs of a massive project like this, we are going to be talking in multiples of $8 billion on the expenditures.

We have to be honest about where those costs are going to be, who is going to be paying for them and whether we have the kind of money, given our budget deficits, to deal with this unless we ask for tax increases to pay for them.

I am not against it. I am just frustrated with coming up with something that I know a lot of contractors will want to pursue, but it is going to cost the taxpayers a lot of money.

I wanted to see, can you give us a warranty that it will be done for $8 billion and no more, and don't you think it is likely the costs will further accelerate in the future?

Mr. Beggs. No, sir, I don't. If I can respond to your early assumption, we estimated a little over $5 billion for the shuttle and that was at 1971 economics.

Now, I can make an argument, and use the same argument the Department of Defense often uses, that the inflation rate through the seventies for the aerospace sector of the economy was significantly higher than for the rest of the economy. You can make that argument. I won't. In fact, in the same economics, 1971 economics, the shuttle system costs $6.75 billion. That is a 30-percent—wait a minute. I am going to give you—concede part of your point. That is a 30-percent increase in the cost we initially projected. However, one has to remember that we had a significant slip in the schedule on the shuttle. It went 3 years late from our earlier projections, and we also ran into some very significant technical problems on the shuttle, both in the integration, things like the tile, and some problems on the engine which put us through the—or over the hurdles in a number of costly respects.

However, I will concede, we were about 30 percent overrun on the shuttle. Now, if you turn to the space station, we have given you an estimate. It is the best we have got right now. We will be refining that estimate through this phase B effort, as I have discussed with this committee a couple of times.

The purpose of putting that fairly lengthy and somewhat more expensive than normal—than is the norm, has been the norm in the past—is to refine those numbers that we gave you, and we will in about a year to maybe a year and a half, be working that problem very hard. If it changes significantly, you will have access to all of the reports that we get from the industry and indeed, I expect that you will make a number of additional trips around the circuit to visit the people who are working with us, so there are not going to be any greater surprises in this thing. And by the time we finish this phase B effort, we will have this system very well designed and configured. We ought to know whether that $8 billion estimate that we have made is right on, or is likely to increase, or even decrease.

I think the Congress in this program is well protected. We are trying to do the job in a very responsible way, taking advantage of the lessons we learned on the shuttle and previous programs.

Mr. Glickman. Mr. Chairman, if I may make 20 seconds more of comments (my bell has rung). I think that is a fair response. I would make a couple of comments: One, I think you should challenge your engineers and people who are building this thing to come up with cost ceilings as a way, so systems are not overbuilt.

I don't want to get into the position we are so far along, it is going to cost us $20 billion, but we have come this far, so let's do it.

In the next 2 years, you are going to develop the cost basis so Congress can make a decision. I don't want to see you hide behind inflation like Mr. Weinberger does all the time.

It is always the net increase after inflation. I never see that in any other Federal program at all, except in defense. I don't want to see NASA hiding behind inflation as a justification for cost increases, and I am not saying you are doing it.

I am letting you know our feelings right now.

Mr. Beggs. I had not made any remarks to indicate we were trying to hide behind inflation as an excuse, but we do estimate these jobs in a specific year's economics. The space station was estimated in 1984 economics. The shuttle was estimated in 1979 economics, and one has to take cognizance of that, when you look at the overrun we have suffered.

As I say, I acknowledge freely, we had an overrun. It was about 30 percent or thereabouts on the original numbers, and that is something one has to be concerned with, because we take pride in our ability to estimate this job.

I think NASA has a record which both this committee and NASA can be proud of. We do not overrun programs with a few exceptions. I got to say, there are exceptions that prove the rule, but with very few exceptions, we have close to our estimates.

Mr. GLICKMAN. Thank you, Mr. Chairman. I appreciate the time.

The CHAIRMAN. Mr. Nelson.

Mr. NELSON. Mr. Chairman, thank you, and Mr. Beggs, I would just underscore to follow up on Mr. Glickman's line of thought, of a concern as we project what the hardware is going to cost, and we protect the space science, as we look to our budgets over the next decade, to make sure that we do not use the science as the pot from which to rob to pay for the hardware.

I would underscore that point, and I would like to say that again, I think you have done a masterful job in putting together a budget, given the constraints that you have had from OMB, and I think you have done, within what constraints you had, a tremendous job in trying to keep alive spare parts for the orbiters, and I want to ask you a couple of questions about that.

Do you think that between now—over the next decade, are we going to see an increased launch traffic demand that is going to see a fifth orbiter in the next decade?

Mr. BEGGS. I wish my crystal ball was clear on this one, Mr. Nelson. I have testified each year I have been in town on what I think I was more optimistic about the market projections I guess 2 or 3 years ago than I am today.

I took a close look at that just recently. I am still optimistic on the market, the overall market. However, I have got to tell you that in this past, about 14 months, in the commercial launch area where we compete with Ariane, and everybody else has to compete, we won five, and they won five, and nobody else won any.

We took 50 percent of the market in that time period and they took 50 percent of the market. We know that the Europeans are coming along very aggressively in developing the improved and increased capability of the Ariane, with the Ariane IV and Ariane V, with the same meeting in Rome where we have approved moving forward with the space station phase B. They also approved going forward with Ariane V development, which is a very significant development. Well over $1 billion will be put into that effort. I have got to be a little bit pessimistic as to our ability to hold the lion's share of the market in the future; so while I am still optimistic about the market, I am not so optimistic that we are going to maintain a very significant lead over Ariane.

At the same time, I am giving you kind of a lengthy answer here—now, at the same time, we have seen in that same period the DOD decide that they want to have a backup, and I cannot gainsay their need for a backup. That is a decision that they have to make, but it does mean that they will take at least two shuttle flights a year out of the manifest in those outyears, and that is significant. We are talking about 20 to 24 flights in the outyears, so you are talking about 10 percent of our flights.

In addition to that, they have been proposing this year, and I take note of the fact that NOAA announced in their budget presentation the other day that three of their satellites have been committed to Titan II's. They were decommissioned last year, taken out of the silos, and they have been offered around town as expendable launch vehicles to be used for Government payloads.

That goes under the rubric of cost saving. Whether it is or not is something I cannot testify for or against. So we are seeing the market eroded from the point of view of competitive vehicles coming in and picking off pieces of the market. And, every one of those hurts us in our future manifest, and when you take all of that into account, there has been a very severe erosion of our position in the market, and while we still are considered to be the primary means, primary national means of launch, there will be in the outyears a significant alternate source of launch capability, and we have to take that into account.

That has been the big problem we have had in justifying a fifth orbiter in this current time period.

Mr. BEGGS. Now, getting back to your question about what about the 1990's. Well, my vision on this would be that sometime maybe towards the mid-1990's, we would—this Nation would go forward with a second generation shuttle system. It will be about time. We have designed these vehicles to fly each orbiter 100 times without overhaul, or 500 times—up to 500 times with overhaul, because we could fly these things well into the second or third decade of the 21st century at the flight rate we are projecting now.

But I think the economics of the thing will dictate that we will want to take another look at the system sometime in the mid-1990's, because by technology moving fast enough we are beginning to see ways where you could cut the cost significantly, single stage-to-orbit and other things like that—better thermal protection systems and so forth.

And that we will want—the Nation will want then to go on to the second generation. Now, the question is do you need the fifth orbiter to get you—to bring you from where we are today to let's say when a second generation system would come into operation, which would probably be sometime after the turn of the century.

I don't have that answer. All I can tell you is that our position in the market has deteriorated since last year.

Mr. NELSON. At what date does the loss of the contractors become prohibitively expensive to start up on the production again?

Mr. BEGGS. Well, we are going to try to extend that a little longer.

Actually, the Rockwell folks will start to come down very significantly in manpower this year as the Atlantis and the mod on Columbia are completed, which will be the middle of the year. After that their work force at Palmdale will almost disappear. We are fortunate, however, that they won't disappear totally, because what they are going to do is walk across the field and go to work on the B-1. That is where most of them are going to end up.

And, indeed, we have had that situation once before. They move on to the B-1 and then when the shuttle comes back they come back across the field, because they like for several reasons—one, in that case the B-1, as you know, was cancelled. But also they like to work on shuttles. They are more intrigued by the work on the orbiter than they are anything else. So I think we can get them back.

But the other side of the problem are the other people that are employed on the pieces and parts down at Downey. And we are going to try using the spares program to keep as many of those folks onboard.

But we are going to start to lose some of the subcontractors this year. So when you say when will it become prohibitively expensive, I would guess, you know, toward the first part of 1987, it is going to start to get fairly expensive.

Mr. NELSON. I commend you for what you have been trying to do to keep alive that option within the constraints that you are dealing, unless we just outright appropriate a whole bunch of new money, which is unlikely.

You have done as good as can be, and you have done it very well.

Mr. Chairman, in conclusion, I will just say that we will follow this up in the space subcommittee in detail. We are going to have some hearings on pricing policy and we will have Mr. Beggs to come back and testify to us on that. And we will dig into this as it unfolds with the Air Force decision on their expendable, on their RFP, as that drama unfolds. We will be getting into the specifics on that and how it integrates into all of this.

Thank you.

The CHAIRMAN. Thank you. Mr. Slaughter.

Mr. SLAUGHTER. No questions, Mr. Chairman.

The CHAIRMAN. Mrs. Meyers.

Mrs. MEYERS. Mr. Beggs, as a new member of the committee I am interested in the commercial programs and technology utilization section of your testimony. Could you expand on that and maybe give the new members a little background on it.

Mr. BEGGS. Yes, ma'am. I will try.

The President's policy, which was ennunciated both in the space policy document and last year in his State of the Union Address, encourages the commercial sector to use both the shuttle and eventually the space station in as broad a way as they care to participate. And it encourages their investment in that activity.

Some years ago this committee and the Congress provided us with the authority to assist commercial entitites which wanted to experiment in space by providing essentially free transportation while they were experimenting. Those are called—the mechanism by which that is done is called a joint endeavor agreement.

It is a formal piece of paper, and what it encompasses is that the company or entrepreneur involved in this thing will agree to invest his own money, their own money, in something that appears to be practical and desirable from an economic and national policy point of view. And, we will fly them on the shuttle into space and allow that experimentation to go forward. The one that has received the greatest note on that is an early one which was drawn with McDonnell Douglas in collaboration with Johnson and Johnson to fly an apparatus called electrophoresis in space. And we have been flying that a number of times.

Indeed, we flew it last year with one of their technicians, one of their engineers abroad, a man by the name of Charles Walker out of St. Louis. It appears that that apparatus and the system has great potential commercial possibilities. It refines or purifies pharmaceutical materials in a way that cannot be done here on Earth. The materials they are looking for sell for typically here on Earth in the order of a few million dollars per pound, so they are the kind of thing that you are looking for to produce in space. And they believe that in a matter of another few years they will go commercial with that, and then, of course, they will pay their way into space, and they are looking forward to the space station era when they can put that apparatus up permanently and visit it from time to time.

We also have agreements with a number of others and are negotiating other agreements with commercial concerns. The kind of concern we are looking for really is a nonaerospace activity. We have drawn an agreement this past year with the 3M Co. and they have submitted us a list of some 72 different experiments that they would like to conduct in space. That is the kind of thing we are trying to encourage. We want them to come and experiment with us, and as we approach the space station era, to think about experimentation and operation on a permanent basis. And the reason I emphasize that is that our ability to experiment in space in the same way that we experiment in a good industrial research laboratory has been one that we have long been working towards.

In space, we have typically sent automated pieces of equipment up we monitor by telecommunications. But you cannot interface with human intelligence while that experiment is in space. What the shuttle enables us to do, with the spacelab, for short periods of time, is to send scientists and engineers in space and interface, work closely with their experiments while the experiment is being conducted. That is exceedingly important, because we know from our past history of industrial experimentation that sometimes the most important results are not those that you set as an objective, but the serendipitous things that you discover quite by happenstance as the experiment is conducted.

So the ability to put human intelligence with the experiment is exceedingly important. And we are starting to do that on a short-term basis with the shuttle. This year we will fly the space lab two or three times and have scientists and experiments onboard all the time.

Some of those flights, incidentally, are flights by our foreign friends who anticipate the same thing. Beyond that, of course, is the invitation to actually go commercial in the space station.

We are encouraging the commercial community to come in and plan to go into the space station on a permanent basis. And we have a lot of interest in that, including some who are interested in putting up a completely commercial laboratory right from the beginning.

So if that happens, they will go permanently in space, and we will have, I believe, a very important adjunct to what we have here on Earth in an industrial facility that we can work and develop.

This budget contains about $30 million to pursue that kind of activity. That is, that is the money we use to assist them when they come to us to help them get aboard the shuttle or eventually do their planning to go further than that.

The CHAIRMAN. Mr. Gordon.

Mr. GORDON. No questions, Mr. Chairman.

The CHAIRMAN. Mr. Monson.

Mr. MONSON. Thank you, Mr. Chairman.

Mr. Beggs, I am sure you are well aware of the considerable interest that you have created in the State of Utah in the next shuttle mission. We look forward to that with great anticipation.

I understand that you are considering a proposal to allow for a second source supplier for—I believe it is the booster rockets for the shuttles. Could you tell me what factors you are considering in making that decision and what the status of that proposal is at this time?

Mr. BEGGS. Well, the status of it is that we have gone out for expressions of interest in the Commerce Business Daily, and we will wait for responses to see what they want to do.

The purpose of what we are doing is to try to encourage a consideration of second sourcing from the industry. The SRB, of course, is the most numerous of the consumable components we have on the shuttle, and as we build up the flight rate to, let's say, 20 to 24 a year, we will be building, of course, two for each flight, and that is in the order of 40 or 50 a year. And that is a lot. So, we think that that is one of a relatively small number of consumable components that could be significantly assisted to—with a second source, to maintain a competitive environment and to assist us if we have surge problems—that is, if we would like to fly a few more flights in any given year, it would assist us in making sure that we had a capability to respond to a surge.

So that is the reason for it. Whether we will do it, however, depends on how the industry responds. If the industry responds with a willingness to invest some money in this as well as require some investment on the part of the Government, we will probably proceed to the next step. But it is going to be a pure economic evaluation, that is whether we feel we can save some money for the Government in the long-term and achieve as a consequence of that savings some other advantage.

Mr. MONSON. Is there a date set for making that decision?

Mr. BEGGS. As I say, we have asked for expressions of interest. I think they are coming in now to allow us to evaluate how well—whether they are willing to make investments in the business. It will probably take us 3 or 4 months to evaluate those and then we will decide whether we will go to the next step.

Mr. MONSON. Thank you.

Thank you, Mr. Chairman.

Mr. BEGGS. Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. Chairman, I had a prepared statement here that I would ask unanimous consent be included in the record at the appropriate point.

The CHAIRMAN. Without objection, we will make it in the record following the remarks of Mr. Lujan.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. Beggs, I heard a news report that indicated that one of the delays of the next shuttle mission related to a paperwork delay and I am wondering whether or not that was an accurate report and, if so, what that portends for the future when we are looking for a far more vigorous schedule of shuttle launches.

Mr. BEGGS. The report is inaccurate, Mr. Walker. I regret that we are probably responsible for the inaccuracy. Because we led the media to believe that was our problem. The plain facts are—as you know, we had a tile problem late last year.

We had to pull several thousand tiles and replace them. We just about completed that. In fact, it is completed down to just a handful. So, that job is finished. However, the thing I think that the media misunderstood is after you put the tile on, there is an additional job that has to be done. You have to fill the gaps, the interstices between each tile are filled with a special material. And, we are in the process of doing it. And that is the current hold-up. It is to fill the gaps.

I think what was said is that—well, I don't know what was said, so I should not try to judge. But I think what they led them to believe was that the job of filling out the paper was the thing that was going to hold us up. That is not the thing that is holding us up. It is actually filling in the gaps that is holding us up. But we do require and have long required a complete paperwork record of everything that is done—everything that is done on the shuttle. And that is a very sound procedure which has been in place in NASA ever since the earliest flights that we made back in the sixties.

So, we do have a paperwork system that has to be completed and closed out before we are cleared for flight. But that is not a significant problem at this point. You have to remember as well, we have flown this vehicle 15 times—we have flown the system 15 times. At some point we will move towards a more automated close-out scheme—it is our intent to do that. But right now, we do—it is primarily a manual system. That is, somebody goes by, inspects, fills out a piece of paper and says the work is complete. We will continue to do that, I expect, for the next several flights, and then we will shift over into a more automated mode. We are working to do that.

But the paperwork system is not holding us up on this flight. It has been delayed about a week, a little less than a week, as a consequence of the tile work that had to be finished.

Mr. WALKER. I just thought that that was the problem. The next public official you probably should fly is somebody from the Paperwork Commission, in addition to the Senator.

I am glad to hear your answer. Thank you.

The high failure rate of the meteorological satellites is cause for some concern. Is there some common problem that can be noted in that failure rate?

Mr. BEGGS. I think it is a common problem—we have got several different failure modes in the system. We think that the ones that we are developing now will be very highly reliable.

You are flying a very complex system in the meteorological satellites. You have got several cameras onboard and quite sophisticated electronics to allow you to make those pretty pictures that we see on the television tube every morning and evening.

As a consequence of that, the electronic system has been the least reliable piece. As a matter of fact, many of those Metsats that are still up there you could use for various communications Sats, but their cameras are out, so they are useless for observation.

That has been the primary source of our trouble. But it hasn't been any single thing in the cameras or the camera systems that have caused them to fail. It has been a multitude of things. And as time has gone on, they have gotten more reliable. They have also gotten smaller and lighter weight.

And I think you will see them become more reliable as time goes on. I should add, I think they have done very well to date considering the technology—the level of technology we were using.

Mr. **Walker**. Just one question, and we will pursue it in the subcommittee. On the question of the space station—from your testimony, you could read that at once we are designing a multipurpose station that will have a number of different functions on it.

In addition, in your statement you talk about the fact that the space industrial park concept is a part of your planning with the manned platforms flying in proximity to the station.

My real question is whether or not we have arrived at any determination as to what we are really going to do, and whether or not as we go about designing a station, whether or not that basic decision has to be made—isn't it far less expensive to design, say a limited purpose space station, than it is a multipurpose space station, and wouldn't we get far more international and perhaps commercial cooperation if, in fact, we had a limited purpose station which then could be added to with the unmanned platforms in proximity.

Mr. **Beggs**. We intend to have the unmanned platforms.

I don't know the answer to your question. I am somewhat dubious—I would be very dubious of a single strength station, designed for a single purpose, simply because while that might be somewhat cheaper, I think cost, effectively, this would be severely reduced. I think the initial station has to cover a minimal number of functions. Certainly, you have got to permit the science activities that we have carried on for a long time. We have been telling the scientists, our science constituency, for a long, long time that we are going to make it easier for them to do their thing in space.

We have promised them that on the shuttle. We are now promising them that on the space station. And I think we have got to fulfill that promise, because if this Nation is to advance its efforts in space science, and certainly space science has been the most important aspect of this program from the beginning, and we have learned—the new knowledge we have gained is incalculable—the new technology we have developed is almost incalculable.

So that is an essential function. I think the commercial activities are an essential function. I think you have got to plan, if you are going to get it up there, we should plan to emphasize to some degree the ability to retrieve and repair satellites, because that will save a lot of money in the future. Beyond that I think we are going to have to rely on the phase B studies to tell us the cost—the cost trades that we are adding or subtracting other functions and we will be prepared to discuss that in great detail.

Mr. **Walker**. Thank you, Mr. Chairman.

The **Chairman**. Mr. Volkmer.

Mr. **Volkmer**. Thank you, Mr. Chairman.

Mr. Beggs, on the space station, you presently plan to continue to have all during the phase C system engineering and integration still basically in-house.

Mr. **Beggs**. Well, we are still examining whether we can do that. We would like to do that, Mr. Volkmer, and the reason is fairly straight forward and simple as to why we would like to do it.

Unlike something like the shuttle, where the program begins and ends in the development and manufacturing phase, we envision the space station to be an operating facility and to be changing over time, probably for the next 25 or 30 years. And, therefore, we would like to have at the end of the manufacturing phase and the launch phase, we would like to have a cadre of systems engineers within the agency that could handle the task in the out years, that would be capable of handling the task in the out years, without having to retain a large industrial activity in that.

And that simply carries on the same policy that we have had in NASA from the beginning, that those facilities that we operate, we like to be able to do the engineering work on them as sometime goes on and as we modify and change them. However, having said that, I will freely admit that we have got to look very carefully as to whether we are going to need help in that task, and whether we have the necessary manpower and resources to do the full job. So we may have to share it with an industrial contractor—still keeping in mind that we want to have residents in NASA at the end some capability in systems engineering.

Mr. **Volkmer**. When will you begin looking at the operating costs on the space station?

Mr. **Beggs**. We will be looking at that during the phase B effort. I expect we will have a fairly good cut on that within 1 year to 15 months.

Mr. **Volkmer**. As long as we are talking about times, on the shuttle when can we anticipate a resolution of the question of the pricing policy for 1988, 1989 and on?

Mr. **Beggs**. I really don't know. It seems like everybody in this town has got a view on what—how we ought to price this thing.

Mr. **Volkmer**. I am sure the members of this committee do also.

Mr. **Beggs**. As a consequence of that, a lot of voices are being heard. We are giving—everybody is being given a chance to weigh in on the issue. It will no doubt take another month or maybe two before all of those views are known and we have the issues highlighted. Eventually I expect a Presidential decision on it. But right now we are still in the process of examining with a number of other people in town what the cost basis, what it is likely to be, and what the competitive situation is around the world.

You can argue as to what the competition is and is likely to be interminably.

Mr. **Volkmer**. Also, I want to congratulate you and I find very gratifying that you have the Office of Space Commercialization. As I understand it, within that we are going to have some initiative, use of space policy, centers for commercial development of space.

Can you give me some idea, or else we can wait until the full authorization hearings, as to how those centers will be instituted and funded and how they are going to differ from our centers of excellence that we have being started.

Mr. BEGGS. Yes, sir. What we are trying to do, we are going to spend about $1½ million this year, 1985, and then something over $6 million is in the budget just submitted to establish several what we call centers of excellence in the commercial arena.

Our purpose is to develop areas of expertise, either in a university or in a consortium of research organizations where an industrial or commercial activity, either an entrepreneur or an established company, can go and work in specific areas. That is, they will not be duplicates of each other in each region. They will each have a specific area that they will work. And they will be different and their focus will be on the applications of technology and we expect them—we have told them, those that have come in and expressed interest, that we expect them to leverage the Government money with private investment. That is, we expect them to go out and get a significant portion of their funding from the private sector, because it benefits the private sector. And no one has raised any questions on that. They all seem to think that that can be done and should be done. So what we will have is a joint private/public activity to look at very specific areas of technology where we hope they can develop useful products and services in space.

Mr. VOLKMER. Mr. Chairman, I have one other question. As we get in after 1986, and we have the space telescope going up, and we also have other science instruments going up—we are going to have operating costs basically on these. We are looking on that impact on the space science and applications budget as far as further research, et cetera, and the impact of operations costs on those and replenishment.

Mr. BEGGS. The operating costs are something that I have been spending a lot of time on, and we have been examining very carefully as to how we can minimize those operating costs. Because, as you rightly pointed out, for the first time we are going to be operating some facilities which have a long life and which require substantial amounts of money each year to get the benefit, to get the full benefit on them. So they will have a significant impact in the out years on the space sciences budget.

We are going to have to, I think, be probably a little more forthright in ending some programs, if we are going to succeed in balancing this budget.

Now, the space science budget is one that we have put a good deal of emphasis on in the last 3 or 4 years. When I first came to Washington, I think we were spending in the order of $900 million in both the space sciences and application, those areas and applications which generally are scientifically inclined or directed. And in this budget that is now up over 1.6 billion, and it is almost a quarter, a little over 25 percent of the R&D in the space flight budget. So, it has increased significantly. How much more we can afford to invest in that area I think is the question that this committee as well as the agency has got to address and wrestle with and come to a conclusion because that will determine how many new starts we can have in the out years.

Mr. VOLKMER. Thank you very much, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Volkmer.

Mr. Henry.

Mr. Smith.

Mr. Traficant.

Mr. **Traficant**. What do you see NASA's role in assisting commercial development in space?

Mr. **Beggs**. What is our role in facilitating and assisting, I guess, in commercial development in space. I think our role is to facilitate. Our role is not to develop or even to render judgments on the things that are brought to us. If it is an appropriate commercial activity and is within the broad objectives that this Nation has to expand and improve its economic activity, we ought to facilitate the company in doing that work, providing, of course, they are willing to maintain investments in their idea. So, we provide the transportation. When the space station arrives, we will facilitate their access and integration into the station.

Beyond that, NASA certainly would not get involved in trying to develop or even to experiment with commercial products. In my view that is not our job.

As a matter of fact, not only is it not our job, if we tried to do it we would flunk the course. We are not good at that. But as a facilitator and as a judge of the schedules and things like that, what can be done; we can help a lot. We will try to do so.

Mr. **Traficant**. I think my question is, What type of interaction is there from any other groups or entities that pursue the same lines, and how do you interact with those groups, and how often are those types of meetings, and do they in fact exist?

Is it just a military situation here, without looking at commercial use?

Mr. **Beggs**. Invite as broad a segment of the industries as will come to one of our research centers. As you know, we have eight centers across the country. We rotate around through the eight centers, and invite them in.

And we explain at those meetings—they are usually 2-day seminars—we explain to them what we are doing; we explain to them how they can get in on those programs; we talk about—we allow them to roam freely through the center to look at the research we are doing, to see whether there is anything there; and, many of them have found there are some things we are doing that they could pick up and move off into the commercial arena.

We also have a very lengthy mailing list where we send them literature and, of course, we do spend time in actually contacting people who express interest.

Ike Gillam, who runs that office, and all of the folks in that office are occupied in a substantial portion of their time in discussions with commercial folks; people who have an interest in some entrepreneurial activity. And, I think we are making progress. In fact, I know we are making progress. There is greater and greater interest in this all the time.

Mr. **Traficant**. I think along those lines, one of the questions is the great achievements you have, are they basically in line with what you are doing or are they now spilling over into the general commercial opportunities that might exist, and are other people taking advantage of those strides, and how might they better be taking advantage of them, and what can we do as a committee to perhaps prioritize that and make that possible?

Mr. BEGGS. Well, I am also asked the question, will NASA's commercialization activities be a success, and my response to that is always. It already is a success.

Over 25 years the list of commercial products which owe a debt to NASA technology is as long as this room is wide. It is a very, very long list indeed, ranging from computer science, solid state electronics, electronic devices many times, medical electronics, industrial gases—all of them bare a debt to the technology that we have developed over the last quarter century. And, indeed, many of our technological developments that come out of the program have gone very, very widely into the industry. They are used by people that we don't even know about. The activity is—has been, I would argue, very, very successful.

Now, with respect to your question, "how can we help in improving their access," You can help by first of all allowing us to continue with the program with whatever guidance you would like to give us as to the degree we should increase our interface with the industry or decrease our interface with the industry. I think it would be a mistake, however, to try to structure this program too tightly. I am a businessman. I come out of the business world where I spent most of my career. I know from long experience that the best way to stifle any new ideas in the commercial world is to try to put fenses around or try to structure it too tightly as to what areas they ought to go in.

We ought to let them roam freely. We ought to say:

> Here we are, here is what we have got, here is how we can help you. We can facilitate, we can give you access to our research laboratories, so that you can use the various facilities we have—the simulators, the large computers, the other things that we have available and our laboratories—we will help you in every way we can, but we are not going to tell you what to do. We are not going to tell you what products we think are most promising or even what areas of research we think are most promising—because I don't think we know—we know what we are doing—I don't want to lead you astray on that, but I don't think we know what part of what we are doing would have the best or most immediate commercial potential.

Mr. TRAFICANT. Thank you.

The CHAIRMAN. Mr. Morrison.

Mr. MORRISON. I will pass at this time, Mr. Chairman.

The CHAIRMAN. Mr. Stallings.

Mr. STALLINGS. I missed the early part of your testimony, so let me just ask a question. You may have already addressed it.

What do you see down the road 25 years for NASA? Wax prophetic for me a little bit, would you?

Mr. BEGGS. Oh, golly, I am going to get in trouble.

Well, in 25 years we will be twice as old as we are today and we will be a whole lot smarter, I hope. So it is not entirely clear as to what we will be wanting to do toward the end of that 25-year period. But some things are fairly clear.

We were interested a year or so ago in going back and looking at what had been written more than 25 years ago. There is a very interesting series of articles that appeared in the old Colliers magazine where Cornelius Ryan was one of the most imaginative guys working in journalism those days, got together a panel of Van Braun, Fred Whipple, Willey Ley, and a flock of others. He said what do you see in the future? That was 1952, 6 years before Sputnik went up. So we dug out that series of articles. And everything we have done in the last 25 years is in there, including the space station. Also in there is a base on the Moon and a trip to Mars. And all of the planetarium exploration, all of the initial flights to the Moon, all of the scientific work, observations of Earth, observations of the universe, exploration of the planetary system, is all in there.

So, clearly, with the kind of vision that the men that wrote those articles had at that time, they could see ahead 25 years or 30 years, actually. They were looking ahead—and maybe even longer than that. So you can look ahead I guess fairly clearly. And with that preface, I think in 25 years we will be operating routinely in a space station or maybe a couple of space stations, experimenting—I think we will be manufacturing. I think we will be probably doing a lot more observation, both looking down at the Earth and looking out at the universe. By that time, very personal communications will be possible. It will be possible for you to talk to any point on the globe carrying around a small transistor that would fit in your pocket, because we will have by that time a very large antenna in space or antenna farms in space that will allow you to communicate using very low power.

We will no doubt have a lot of other applications which I can only guess at, at this time. Clearly, the possibility of exotic materials development in space is very much something that is likely to come along.

In exploration, we will no doubt—I don't think we will have done it, but we will no doubt in 25 years be considering a permanent base on the Moon or a conceivably human exploration of Mars. And the existence of the space station infrastructure will make that a very real possibility.

We will also be doing an increasing amount of looking out at the universe. I think we are right on the verge with the large space telescope and the other array of astronomical instruments we are talking about putting up in the next 10 years in understanding some of the most profound mysteries that mankind has tried to address since the beginning—things like how did the universe begin; how will it end, what is happening in the universe; how do all the forces of the universe fit together in a unified way.

The answers to those questions will change our lives profoundly here on earth, because they will enable us to do things that we can only dream of doing right now. And beyond that, I guess by that time we will maybe even be thinking of the kind of thing that Prof. Jerry O'Neill up at Princeton likes to talk about, and that is colonies in space, because all of those things will be possible. We will be no doubt flying, or be into the flight program on a second generation shuttle I believe which will give us much more ready access and cheaper access to space.

Those are things that you can see right now. There are a lot of things I am sure we cannot see that we will want to do. Twenty-five years in this business, though, is a relatively short period of time. There is nothing that we initiate in the program that doesn't take 10 years to accomplish.

Mr. **Stallings**. Why I asked that question, you are one of the few Government agencies that has continued to receive high marks from the general public. There is still a lot of support for the kinds of things you are doing. And I would hope—one of my interests in this committee is to find this out—that the 25-year objectives are something that is going to benefit. I see two different levels of scientific activity. One, nice to know kinds of things. Others that will have pertinent meaning to the way of life and the standard of living here upon this planet.

Mr. BEGGS. The Commission that was established by the Congress last year with the leadership of the chairman and Mr. Lujan will address those issues. And I think from what I understand of that Commission, they will be able to do a very good job in laying out those objectives.

If Von Braun and Ley and Whipple and company could do that in 1952 with the knowledge that we have of what we have done in the last 25 years I think we can do a very good job of laying it out for the next 25 or 30 years.

Mr. STALLINGS. Thank you.

The CHAIRMAN. Mr. Mineta.

Mr. MINETA. Thank you, Mr. Chairman.

I apologize, Mr. Beggs, for having to bounce in and out during your presentation this morning.

I am wondering, if it hasn't been covered already, if you would be able to summarize for us the current status of NASA's consideration as to whether or not you want to split the space shuttle solid rocket motor production between separate contractors or whether you will continue to keep the production work at a single contractor?

Mr. BEGGS. I did respond to that question, Mr. Mineta. In brief, the answer is, "I don't know." We have solicited the industry for interest in setting up a second source. We are just getting their response back.

In fact, I think they are in now. We have not evaluated them. We will be evaluating them in the next 3 or 4 months fully, and then we will decide whether we ought to go out for a second source.

But the SRB is the highest quantity component, consumable component that we have on the shuttle. As we proceed toward 20 or so flights a year, we will be buying 40 or 50 per year, and that is enough quantity that we think it might justify a second source, both from the point of view of economy. That is, we think the competitive posture that could be established there would help us get the cost down somewhat more. And from the point of view of providing assurance of supply and allowing us to count on a surge capability if we were to want to fly maybe two or three more flights in a given year.

So we are looking at it, and the decision that we will make, of course, we will keep this committee informed. But the decision we will make will probably be based almost totally on the economics of the thing. And we don't know yet what the industry response is. At least I don't know yet what the industry response is going to say with regard to economics.

There is another issue that I should have mentioned at the time, and that is there are potential and other uses for the SRB. It could form a basis of a heavy-lift vehicle which, if we were to decide sometime in the future we would need it, would require additional quantities of SRB's.

Mr. **Mineta**. Well, I know that if you find that NASA could save the taxpayers money through dual sourcing, you would pursue that in a vigorous manner.

I appreciate your comment about keeping this committee informed of the progress of the developments on that issue. I know I would appreciate it if you would keep us informed.

Mr. **Beggs**. Yes, sir.

Mr. **Mineta**. I notice in your testimony references to the numerical aerodynamic simulation program. And, of course, that is something that we are very proud of out at Ames and the work that is being done there. So, again, I want to thank you for that effort on the part of NASA.

The other thing I would just very quickly like to ask—how is Secretary Aldrich and your conversation coming along, if any, as to the whole issue of the fifth orbiter and for the ELV? Is there anything going on at all?

Mr. **Beggs**. We are heavily engaged in discussions. We owe a report to the Armed Services Committee on our deliberations on that subject which is overdue right now. But we have not been able to frame it up completely, but we hope to in the next couple of weeks. As far as I know, the DOD has not changed its position at all as to the requirement for a backup launch system. And that is not at issue. We have no quarrel with that, but the ongoing discussions are really concerned with the potential for moving from the current family of ELV's to higher-lift, and what the best way of buying in a current family ELV would be with respect to developing further capabilities in the out years. We don't totally agree on that.

Mr. **Mineta**. Wasn't there some discussion to a—I have forgotten the phraseology—whether it was space shuttle conformability?

Mr. **Beggs**. What we call shuttle-derived versus unconnected ELV's. As I say, that is still at issue with us. We haven't resolved all the issues connected with that. That is the reason our study is late, our report is late.

Mr. **Mineta**. My time is up. Thank you very much.

Thank you, Mr. Chairman.

The **Chairman**. Jim, an issue that has raised some concern with me, as I understand there has been some reduction made in the headquarters staffing for science and applications. It seems to me that—I assume this is being parcelled out to the various centers. It appears there would be an inherent conflict of interest between the centers operating these programs and the headquarters, because the centers oftentimes are competing with the universities for some of this funding.

In the past, headquarters was staffed up when projects have gotten in trouble. A most recent example is the space telescope. And we do have some very complex science development projects coming up. And it seems to me if we get into cost overruns and schedule delays that we won't have an adequate headquarters staff to oversee those projects.

Mr. **Beggs**. Yes, sir, I did have——

The **Chairman**. I understand some of those positions were shifted over to positions in the space station initiative.

Mr. BEGGS. We did take some cuts in the various offices when we established the space station office. That is true. I had Don Hearth from Langley—Dr. Hearth, as you know, has had an avocation of looking at program management over the years, has done some studies that this committee is well familiar with. And, I asked Don to take a look at headquarters staffing and the general relationship between the headquarters and the centers over the last 3 months which he has done. And he made some recent recommendations to me as to staffing increases and decreases in headquarters.

Actually, we didn't change the totals at all. We did shift some complement around within the offices. In that shift, which took place, I guess the announcement to the office went out just a few days ago, we actually increased the code E complement. We gave them several additional—I forget how many.

The CHAIRMAN. Ten or twelve?

Mr. BEGGS. The Space Science and Applications Office. He recommended an increase. And I agreed with that. So we gave them several additional positions to assist them, primarily the program management and science management activity. I have had—I will be quite candid—I have had an ongoing discussion with the Space Science Applications Office for sometime because I am not totally satisfied with the current structure with respect to the management job that they have to do.

The Office, I think, in my judgment, does require some additional tailoring and they are trying to come to grips with that right now. That is the basic organization of the Office. But not the complement. We have not landed on them, nor have we transferred to the centers any of the complement that they have.

Now, we are redrawing the management instructions with respect to the rules and missions of the headquarters offices and the center offices, to try to clarify those relations, and I have signed off on that, or will sign off on it today—I don't know which. I cleared the final draft, and you will get a copy of that. You can judge for yourself whether we clarified it in a way that will impact somebody adversely. I don't think we did.

Our purpose for that was to make very clear to the program managers at headquarters what their responsibilities were and are, and have tried to make very clear to the center directors and the project managers in the centers what their role and missions and responsibilities are.

Again, being very candid, I have been a little dissatisfied with the role of the center director in the program. In some cases, our center directors were acting as bystanders in the program management activities. It wasn't that we were not involved, but it was that they were not involved helpfully, nor did they really consider that their responsibilities encompassed the role of program management.

And, so, we have clarified and emphasized that the center director has a very direct and important responsibility there.

Now, that is clarification in my eyes. If after you have read that management instruction you feel that we have further problems, I would be pleased to discuss it further.

[The information follows:]

NASA

Management Instruction

NMI 7120.3
Date February 6, 1985

Responsible Office: N/Office of Management

Subject: SPACE FLIGHT PROGRAM AND PROJECT MANAGEMENT

1. PURPOSE

This Instruction establishes NASA policies, responsibilities and procedures on NASA space flight program and project management. It is applicable to that portion of project approval and management involving Program Associate Administrators (PAA's), Field Installation Directors (FID's), Program Managers, and Project Managers.

2. APPLICABILITY AND SCOPE

a. This Instruction is applicable to NASA Headquarters and field installations.

b. This Instruction applies to all space flight programs and projects which involve significant resources, high public visibility, and/or critical schedule impacts to NASA or other agencies. This Instruction specifically includes those projects comprising Space Flight Programs as defined in paragraph 3b. Certain ground-based projects, such as for major facilities and information systems, may be governed by this Instruction. It specifically excludes:

(1) Space Flight Program operational activities which are open-ended (such as the Space Transportation System and Tracking and Data Acquisition);

(2) Those projects comprising ground-based Technology Programs and ground-based Space Science Programs as defined in paragraphs 3c and 3d;

(3) Exceptions granted by the Administrator for other specific programs.

c. This Instruction describes the process generally followed in planning and implementing projects. It may be modified to adjust for differences in terminology or approach as best fits the circumstances of a particular effort.

3. DEFINITIONS

For the purpose of this Instruction, the following definitions apply.

a. Program. A related series of undertakings which are funded for the most part from NASA's Research and Development (R&D) appropriation, which continue over a period of time (normally years), and which are designed to pursue a broad scientific or technical goal.

b. Space Flight Programs. Programs characterized by: design, development and operations of spacecraft, their launch vehicles and/or science and technology instruments; relatively high funding levels; firm schedules; and firm technical and scientific objectives. They often involve more than one NASA field installation providing different portions of the project requirement in conformance with an overall schedule. In addition, they frequently require close interfaces between several Headquarters program offices. Individual projects are planned to be an integral part of an overall program (such as the exploration of the planets) and, usually, receive high external visibility during formulation, advocacy and implementation.

c. Technology Programs. These programs are focused on ground-based efforts and are characterized by: research/advanced technology having a relatively low and level of effort funding; the common occurrence of changes in program directions in response to unexpected results; and relatively loosely defined schedules for program accomplishments. The R&D is performed by the NASA field installations, industry and universities. The out-of-house effort is an adjunct to the in-house program, and is, therefore, managed by NASA's field installations.

d. Space Science Programs. Programs focused on ground-based efforts characterized by: research/advanced technology in the space sciences; relatively low and level-of-effort funding; changes in program directions in response to unexpected results; and relatively loosely defined schedules for program accomplishments. (These programs do not include space flight programs, i.e., the subject of this NMI, and do not include materials processing and others similar efforts which are better described as technology programs.) Space Science programs are national in scope with the R&D performed at universities, NASA field installations, and other laboratories. The management of these programs is focused at NASA Headquarters.

e. Project. A defined, time-limited activity with clearly established objectives and boundary conditions executed to gain knowledge, create a capability, or provide a service. A project typically encompasses design, development, fabrication, test, data analysis and distribution, information extraction, and as applicable, operation of advanced aeronautical or space hardware. A project is normally an element of a program.

f. Program Director/Manager. The official in Headquarters who is the focal point for all Headquarters activities bearing on a project or group of projects.

g. Project Manager. The official, usually located at a NASA field installation, who is responsible for executing to completion the design, development, test, and operation of a project within a given set of boundary conditions (technical, cost, schedule, and organization approach). When major projects are assigned to multiple installations, the senior individual in a subordinate installation may also be titled Project Manager, although that person would be responsible to the lead field installation Program/Project Manager having overall project responsibility.

h. Definition Review. A review of a proposed new project by a nonadvocate team appointed by and reporting to the PAA. The review includes but is not limited to clarity of objectives, thoroughness of technical and management plan, maturity of technologies required, technical complexity, technical risks, schedule risks, cost estimates, contingency reserve allowances, and schedules.

i. Project Initiation Agreement (PIA). An agreement between a PAA and FID(s) outlining a new project's management and technical interfaces, procurement or in-house acquisition strategy, schedules, resource estimates, uncertainty (technical, schedule, and cost risks), contingency reserves, and all other key ground rules. The PIA is superseded by the approved Project Plan.

j. Project Plan. A detailed plan which, when formally approved, sets forth the agreement between a PAA and the involved FID's and defines the guidelines and constraints under which the project will be executed.

k. Contingency Reserves. Resources (funding, schedule, etc.) allocated for the resolution of potential problems in assuring compliance to the specified project scope. These reserves are under the control of the Project Manager who shall report their status.

l. Allowance for Program Adjustment (APA). Resources allocated for: the resolution of unforeseen major problems; expansions in mission requirements resulting from changes in project objectives or scope; project stretch-outs, etc. These reserves are under the control of the Headquarters program office.

4. POLICY

The effective management of high-risk projects is at the heart of NASA's responsibilities. Therefore, in planning and implementing projects, NASA will adhere to the following policies:

a. NASA welcomes and accepts the challenge of carrying out projects expeditiously and at minimum cost that demand advances in technology and whose objectives are consistent with Agency and national goals.

b. One of the keys to successful project execution is adequate project definition. Agency approval will be based on adequate and comprehensive studies to: understand the full range and implications of a project's technical content; quantify the risks associated with the proposed work; and identify the schedule, cost, and performance contingencies necessary to permit making meaningful internal and external commitments. Agency approval will be based on these definition studies, a nonadvocate review process, and consultation with field installation management by Headquarters management. While high risk is inherent in the work done by NASA, every effort will be made to understand and quantify this risk before seeking Presidential and Congressional commitment to a project. The desire to obtain project approval or to proceed with project implementation normally should not be permitted to interfere with the adequate and comprehensive studies and cost analyses necessary to define the risk so as to minimize the potential for cost overruns and schedule slips.

c. When NASA goes forward within the Executive Branch or to the Congress and the public, its word must be reliable, its reputation honorable, and its performance unassailable. The entire NASA organization is responsible for reaching these goals. The program offices are particularly accountable for meeting NASA's program management objectives.

d. Roles, responsibilities, interinstallation relationships, and delegations of authority which govern program and project management and execution will be formally and clearly stated and documented and will be in accordance with paragraph 5. This statement shall provide for direct communication between the Program Manager and Project Manager(s).

e. The assignment of field installation responsibility for the implementation of a project will be made early in the definition phase. Likewise, the FID, in consultation with the PAA, will appoint the Project Manager as early as possible. The Project Manager will usually remain with the project until completion of the development and initial operational phases.

f. During Program Formulation, primary responsibility lies in NASA Headquarters. Once a program/project is approved and funded, the principal responsibility for Program/Project Implementation shifts to the field installation.

g. The line of management responsibility, authority and accountability for approved programs is from the Administrator to the PAA to the FID. The PAA represents the Administrator in managing agency programs and has the Administrator's authority and responsibility to insure successful accomplishment within agreed-upon constraints. Each PAA develops a management relationship with the FID's that will permit the exercise of this responsibility. This may include delegation of a portion of the PAA's authority to a Headquarters Program Director/Manager. The FID delegates implementation authority to the field installation Program/Project Manager. While program accountability continues to rest with the PAA and the FID, day-to-day communications and coordination for Program/Project Implementation are normally between the Headquarters Program Director/Manager and the field installation Program/Project Manager.

h. Field installations will be granted authority over sufficient resources to implement a project, including contingency funding necessary to meet unanticipated problems. The program office will reach agreement with the field installation on funding levels necessary to attain this objective. (For a multi-field installation program/project, the program office will establish this agreement with the lead field installation.) Any additional contingency (i.e., APA) which may be added at the Headquarters level may or may not be controlled by the PAA to meet either program changes or additional unanticipated requirements.

i. Prior Headquarters approval will be required if it is necessary to move outside of agreed upon project boundaries of objectives, schedules and budgets. Such changes will be formally reviewed, agreed to, and documented.

j. Information must be provided to Headquarters on a continuous basis. This information must be sufficient to permit assessment of progress and must place particular emphasis on the avoidance of surprises. Headquarters and field installation management will guard against using this information flow to provide the basis for day-to-day control by the Headquarters program office.

k. Normally, NASA will use the private sector to execute projects; however, a number of projects will be selected for in-house execution to ensure that NASA installations maintain technical skills and development capabilities relevant to the effective management of out-of-house projects.

l. Procurement approaches will be used that highlight industrial competition prior to contractor selection and, after selection, allow development of a working industry-Government partnership to carry out the project, placing incentives so as to motivate contractors to meet cost, schedule, and quality commitments. Selection of contractors will be based primarily on technical considerations, management capabilities, cost credibility, and past performance (including demonstrated hardware concepts vis-a-vis studies). Selection of demonstrated poor prior performers, or those lacking meaningful experience reasonably relatable to particular requirements is discouraged and is not in the overall best interest of the Government in the absence of other compelling reasons. NASA source selection officials must be attentive to the credibility of resource and cost proposals when selecting contractors. Selections should not necessarily be made on the basis of lowest cost when there is reason to believe resource requirements are understated by the proposer. Unrealistic resource proposals will be judged to reflect a lack of understanding of the requirement and result in a lower mission suitability evaluation.

5. RESPONSIBILITIES

a. Line of Responsibility. The successful execution of programs and projects governed by this Instruction requires a formal management relationship between the various agency organizational levels in order to maintain the necessary discipline on schedule, technical capability and resources. This relationship is such that the NASA Administrator, the PAA's, their staffs, and the NASA field installations all have significant roles in the planning, budget decisions, advocacy, and implementation of NASA programs and projects. The line of management responsibility, authority, and accountability for approved programs is from the Administrator to the PAA to the FID. The PAA represents the Administrator in managing Agency programs and has the Administrator's authority and responsibility to insure successful accomplishment within agreed-upon constraints. Each PAA develops a management relationship with the FID's that will permit the exercise of this responsibility and, at the same time, preserve the need of the FID for local independence and day-to-day flexibility in program/project management. This may include delegation of a portion of the PAA's authority to a Headquarters Program Director/Manager. The FID delegates implementation authority to the field installation Program/Project Manager. While program accountability continues to rest with the PAA and the FID, day-to-day communications and coordination for Program/Project Implementation are normally between the Headquarters Program Director/Manager and the field installation Program/Project Manager.

When a lead field installation is designated for a multi-field installation program/project, the normal lines of authority are as follows:

(1) For the lead field installation - from the Administrator to the PAA to the lead FID to the lead field installation Program/Project Manager to other lead field installation manager(s); and

(2) For the other field installation(s) - from the Administrator to the PAA to the lead FID to the lead field installation Program/Project Manager to the other field installation Project Manager(s). The other field installation FID's are accountable for successful implementation of their installation's project(s).

In other cases, multiple FID's may have parallel relationships, such as in the provision of launch vehicle support to a spacecraft program.

b. Program Formulation Responsibilities. The primary responsibility for Program Formulation lies in NASA Headquarters. (It is, of course, expected that in most cases the original concept for a given mission will originate at the grass roots level within a field installation.) The Headquarters program offices have the responsibility for establishing individual missions,* technical and scientific objectives, payload selection, timing, marketing strategy, center assignments, cost parameters and advocacy. Field installation personnel are responsible for supporting this effort and are specifically responsible for providing technical, cost, and schedule inputs. Field installations are also responsible for supporting program advocacy.

c. Program Implementation Responsibilities. Once a program/project is approved and funded, the principal responsibility for Program/Project Implementation shifts to the field installation. The field installations have full authority for management of the project within the agreed upon boundaries of objectives, schedules and budget. The Headquarters responsibilities are: general management and oversight; continuing advocacy; a provider of information to higher levels of NASA management, Office of Management and Budget (OMB), and the Congress; and coordination with other Government agencies at the policy level. The Administrator will hold the PAA accountable for satisfactory implementation and the PAA's, in turn, will hold the FID's accountable for satisfactory implementation.

d. Responsibilities for Multi-Field Installation Program/Projects

When a lead field installation is designated for a multi-installation program/project, the lead field installation should be delegated management authority for both the technical and fiscal resources of the program/project and Headquarters should deal with the program/project through the lead field installation. This delegation does not remove the responsibility from the PAA; rather, it refocuses exercise of that responsibility to policy, overall direction, and oversight. If an issue across field installations cannot be resolved by the lead field installation, it is the responsibility of the PAA to assure that such issues are resolved equitably and in a timely manner. Where programs involve other program offices and/or customer constituencies, the Headquarters role also involves marketing, assuring that customer demands and satisfaction are met, and cross-program coordination.

e. Specific Responsibilities of Program/Project Principals

(1) The Administrator is responsible for long range Agency goals and objectives, reviews and approval of new start proposals, and oversight of the overall NASA program.

(2) The Program Associate Administrator deals directly with the Administrator on all matters pertaining to program initiation and continuing management. The PAA's primary functions are to:

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*The management of supporting research and technology and studies in direct support of mission planning is the responsibility of the program office; however, conduct of the technical activity is the responsibility of the field installation and the details will be managed by them.

(a) Direct the formulation of candidate new program starts (including program options) and consult with FID(s) on program formulation decisions.

(b) Work with the Administrator in selecting and establishing new program starts.

(c) Select the members of a nonadvocate team who will perform the Definition Review and report the results to the cognizant PAA.

(d) Assign the project to a field installation.

(e) Sign the PIA with the involved FID's.

(f) Develop an appropriate relationship with the FID and establish any delegation of PAA authority to a Headquarters Program Director/Manager.

(g) Approve and sign the Project Plan.

(h) Assure agreed project funding to the project field installation and control the APA.

(i) Provide oversight of Program/Project Implementation.

(j) Serve as liaison with the Administrator during the life of a program, providing current program status.

(k) Participate in selected project reviews.

(l) Assess the project execution performance of the FID.

(3) The Institutional Associate Administrator (IAA) is responsible for concurring in the assignment of projects to field installations under the IAA's institutional direction based on an assessment of the roles and missions of the installation and the availability of institutional resources. The IAA is also responsible for ensuring that project performance is appropriately reflected in the field installation performance review and the FID's performance appraisal. The IAA is also responsible for ensuring a project is adequately supported once its assignment to an installation has been concurred in.

(4) The Program Director/Manager is the senior NASA focal point for all NASA Headquarters activity bearing directly upon those projects and other activities of which the program is comprised. The Program Director/Manager is responsible for Program Formulation and for developing and administering the Headquarters guidelines and controls under which those projects comprising the program are implemented. The full extent of the Program Director/Manager's authority will vary from program to program, but will normally include:

(a) Developing and establishing initial program objectives and long range policy guidelines.

(b) Resource review management, including recommending and managing the program budget and the APA.

(c) Initiating the Definition Review and assuring appropriate recommendations are implemented.

(d) Recommending approval of the PIA and the Project Plan and associated changes to these documents.

(e) Establishing controlled milestones and reviewing performance to ensure their accomplishment.

(f) Establishing and maintaining a close and effective working relationship with the Project Manager.

(g) Performing interproject coordination with other Headquarters elements, and serving as the NASA representative for the program with other Government and non-Government entities.

(h) Keeping the PAA apprised of program status and preparing status reports and other documents required by the PAA.

In essence, the Program Director/Manager is the external liaison for a project: working problems at NASA Headquarters; preparing testimony and justification for Presidential and Congressional authorization; working with other Government and non-Government organizations interested in or participating in the project; and monitoring project execution, relating it to NASA as a whole, and controlling significant variations from the approved Project Plan.

(5) The Field Installation Director is accountable for project implementation.

(6) The Project Manager is the senior official at the NASA field installation exclusively responsible for the implementation of a project within guidelines and controls prescribed by NASA Headquarters and installation management.

6. PROJECT EVOLUTION

a. Formulation and Definition of Candidate Projects

(1) New project ideas and program needs flow primarily from the efforts expended by the NASA field installations on in-house and contracted advanced research and technology studies, from activities of various advisory structures, from the knowledge gained from past and ongoing programs, and from activities performed by various private sector

groups. A selection of the more promising ideas to be defined in detail will be made by the PAA in consultation with cognizant FID(s). The PAA will review the more promising candidates with the Administrator. They will agree on those which will be pursued further. They also will agree on those projects whose planning will be reviewed by the Administrator.

(2) Upon selection of those projects warranting further definition work, the PAA will have the FID initiate a project definition effort and prepare a proposed PIA. The FID will designate a Project Manager and organization to organize, plan, and direct the project definition. The PAA will ensure that Announcements of Opportunity, when appropriate, will be issued in time for the instrument selection to have a meaningful impact on project definition.

b. Definition Review. When the Project Manager and FID agree they are ready, a formal definition review will be conducted by a team selected by and reporting to the PAA. The Definition Review Team (DRT) will be composed of experienced project management, technical, and fiscal personnel drawn on an ad hoc basis from organizations who will not participate in the implementation of the proposed project. The review will assess the actual stage of project definition in terms of the clarity of objectives, thoroughness of technical and management plan, technical complexity, evaluation of technical, cost, and schedule risks, and contingency reserve allowances in schedule and cost. The DRT will provide an evaluation to the PAA and the project field installation.

c. Project Initiation Agreement Execution. A signed PIA is required after definition work is complete and before NASA requests implementation funding. The PIA is the agreement between the PAA and the FID which affirms their acceptance of the defined project's parameters and boundaries and their willingness to make external agency commitments on those parameters. (If appropriate, the PIA will be concurred in by the IAA.)

d. Project Plan. A Project Plan will be prepared after its budget has been approved by the Executive Branch and when the project has reached an adequate stage of definition. All Project Plans will be signed by the appropriate PAA and the FID with the concurrence of the cognizant IAA. The Project Plan will serve as the basic agreement for the project between the PAA and the FID's participating in the project. The Project Plan shall specifically define any delegation of the PAA's authority to a Headquarters Program Director/Manager. Approved Project Plans will be required for all projects prior to Headquarters releasing implementing funds to the project field installations.

The CHAIRMAN. I am not implying that I am opposed to decentralization of some of the responsibilities from headquarters to the centers. I think in many cases, that is necessary, such as in the space station shuttle management, launch activities, and et cetera.

It seems to me in the Space Science and Application Center, this cuts across a lot of lines, and you do have in my judgment a potential conflict of interest between the centers trying to administer the program that they are trying to get for their own funding, and it could be better, I think, managed from the headquarters with maybe some center supervision, but that is a fine-tuning.

Mr. BEGGS. We are not trying to impact that in favor of the centers, or in favor of anybody else. We intend to maintain the peer group review process for allocation of those funds in those programs, and we intend to maintain a strong headquarters role in the way that those funds and projects are divided up as between centers and the outside world.

The CHAIRMAN. I know that the centers are interested in getting funds for projects, say as an example, the astronomy, the center might be trying to expand their activities and other groups and universities, et cetera, that are willing also to compete for those funds.

You are looking at the same horse in the mouth that is going to be giving the funds away, so that is a concern that we have and we need to be very careful about not creating that type of situation.

We have this in the Department of Energy and other Departments that are similar to NASA, where national labs are administering, viewing programs, and they are competing for them themselves, so this is one area that I think there is some legitimate need for strong leadership at the headquarters level.

Mr. BEGGS. There is a natural conflict there, and it has to be guarded against. I agree, the headquarters has a strong role. It is not my intent, nor was it, I am sure, Dr. Hearth's intent to reduce the headquarters role in the overall management of the program, and the allocation of the money. That can't be done. I don't think we can delegate that to the centers. The intent clearly was to try to spell out some of the roles that are played by the various participants in a way that we could clear up what we felt were problem areas that we have had in the past.

We have had some cases, and this committee is well aware of some of the cases, where programs started to overrun, and we have not always been as quickly and forcefully on top of those problems as I would have liked to have seen.

It is for trying to clear up that kind of thing that we are making the move that we are making. It is primarily in the program management activity in the space sciences that our concern has fed down into the organization, and that area, you got to always worry about that, because it can very easily drift, if it is not holed up short from time to time.

That is what we are trying to do.

The CHAIRMAN. Any of the members have any further questions?

If not, thank you very much, Jim. We appreciate you being here this morning. The hearing is adjourned until 1:30 this afternoon, when we will resume with Doctor Block, the head of NSF.

[Whereupon, at 11:35 a.m., the committee was adjourned.]

1986 NASA AUTHORIZATIONS

TUESDAY, FEBRUARY 19, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met, pursuant to call, at 2 p.m., in room 2318, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. Nelson. The meeting of the Space Subcommittee will come to order.

It is my privilege to introduce two distinguished guests that we have, two members of the Japanese Diet. We are delighted to have you, Mr. Aichi and Mr. Watanabe. Would you all stand and be recognized?

Today, the Subcommittee on Space Science and Applications begins its examination of the NASA fiscal year 1986 budget request. On February 6, the full committee heard from the NASA Administrator on the overall budget request including the President's space station initiative.

Today we will examine in greater detail the budget request for the Office of Space Station and the Office of Space Tracking and Data Systems.

Our first witnesses will be Mr. Philip E. Culbertson, NASA Associate Administrator, Office of Space Station, and Mr. Neil B. Hutchinson, Manager of the Space Station Program at Johnson Space Center.

Our final witness will be Mr. Robert O. Aller, NASA Associate Administrator for Space Tracking and Data Systems.

This is our first official meeting as chairman and ranking member, and I am delighted to have a partner in Bob Walker as the ranking member.

Mr. Walker. Thank you, I look forward to working with you, too, and I would like to join you in welcoming our witnesses here today, and I would like to take this opportunity to welcome our new members, Jan Meyers of Kansas; Bob Smith of New Hampshire; Joe Barton of Texas; Frank Slaughter of Virginia; and Dave Monson of Utah.

Each of these people specifically picked this subcommittee and are looking forward to being able to work with the folks on your side this year.

Today we are about to launch our annual examination of the President's budget request for NASA. This is a year of budget constraints tighter than any seen in the history of the agency. We will be faced with several major decisions which may well affect our ability to utilize space for decades to come.

There are studies which indicate that with the right incentives, we can develop a $1 trillion a year space economy by the year 2010, and that economy could grow to $4.5 trillion by 2050.

One of the key elements in a growing space-based economy is a permanent manned presence in space. Today, we will begin our examination of the Space Station Program. This is the largest and most important project currently in development. It is the next logical step, and one which this committee has strongly supported.

We will also be looking at the operations of the Office of Space Tracking and Data Systems. The first tracking and data relay satellite, TDRS-A, was launched in April 1983. After the failure of the upper stage, TDRS-A finally reached the proper orbit 2 months later.

We understand that the technical problems which have rendered TDRS-A only 70 percent operational have been identified and corrected on TDRS-B which will be launched on the next flight. The third satellite, TDRS-C, will be launched later this year.

We are particularly interested in ensuring that during the transitional phase, until TDRSS becomes fully operational, we maintain sufficient communications assets to ensure flight safety.

In addition, I would also request that Mr. Lujan, the ranking member of the full committee, be permitted to submit a statement and questions for the record.

Mr. **Nelson**. Without objection.

Mr. Culbertson.

STATEMENTS OF PHIL CULBERTSON, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE STATION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY JOHN D. HODGE, DEPUTY ASSOCIATE ADMINISTRATOR AND JOHN P. SHEAHAN, DIRECTOR, BUSINESS MANAGEMENT; AND NEIL B. HUTCHINSON, MANAGER, SPACE STATION PROGRAM, JOHNSON SPACE CENTER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY JOHN W. AARON, DEPUTY PROGRAM MANAGER, JOHNSON SPACE CENTER

Mr. **Culbertson**. Thank you, Mr. Chairman. It is a pleasure to be here today.

Before I begin, however, I would like to introduce the rest of us here at the table. Most of you know John Hodge, to my left, who led the space station task force for nearly 2 years before we formed a full program office to manage the program. John is my deputy. Beside him is John Sheahan, my Director of Business Management in the Office of Space Station, and to my right is Neil Hutchinson, who last spring was named as the Space Station Program Manager at the Johnson Space Center. Neil has spent most of the last 6 months directing the activities of the source board which, in about 2 months, will lead to Phase B Program definition studies. John has held the program together while Neil has held the source board.

With your permission, both Neil and I would appreciate the opportunity to begin the hearing with a few words on the program from our respective vantage points, submitting our full statements for the record.

Last year, President Reagan directed NASA to develop a permanently manned space station, and to do so within a decade. Congress supported this initiative by providing the authority and funds to begin the initial planning.

The program's goal, shared by both Congress and the President, is to assure U.S. leadership in space during the 1990's and beyond.

This afternoon, I would like to review the program with you, explain the fiscal year 1986 space station budget request, and continue with Congress the dialog on space station that we in the agency have found extremely helpful as we have attempted to mold the program in a way that would best fit the national goals and objectives.

The Space Station Program is characterized by a number of key features. I would like to comment on three of them which will have a major impact on our activities during the next 2 years.

Detailed information: We are initiating a detailed study and carrying out a broadly-based technology program in order to develop a thorough understanding of technical, cost and schedule parameters before proceeding to hardware development.

This approach of minimizing risk through detailed definition was a principal recommendation of a major study on project management within NASA conducted in 1980 at the request of the full committee.

Second, we are examining, in increasing detail, the mission and payload requirements of the scientific, commercial and technology development communities that will become the customers of the diverse capabilities of the space station. We have incorporated them, and will continue to do so, in our technical planning and in our organizational arrangements.

As you know, President Reagan invited our friends and allies abroad to participate in the Space Station Program. The space station was on the agenda of the London Economic Summit, at which the Summit nations welcomed the U.S. invitation and acknowledged the benefits of such a program to technological and economic growth.

Discussions within Europe, Canada and Japan have progressed significantly since we testified last year. I am confident that agreements on parallel definition and preliminary design activities will be concluded soon and that they will lead to the study and development of program elements for which the partners will assume financial and technical responsibilities.

The space station is unlike any other program NASA has undertaken, for it will be a permanent facility in space, evolving in capabilities as user requirements and appropriate technologies evolve. No longer will we simply visit space. When the space station becomes operational, we will be living and working in space around the clock, 365 days a year, well into the next century.

The evolutionary character and the permanent nature of the space station make it truly unique. They place new and difficult engineering and management challenges upon NASA and her industrial partners. But in meeting those challenges, we have an opportunity to develop a space resource which will establish a new level of capabilities for U.S. operations in space.

The space station will consist of a manned base and associated unmanned platforms, as well as collateral support equipment.

In response to a congressional directive, we are carefully analyzing the potential for the extensive use of automation and robotics aboard the space station and for utilizing the space station as part of the national program to advance these technologies.

The space station will be a versatile and effective facility, serving a diverse range of functions. It will be a national laboratory in space; a permanent observatory; a servicing facility where payloads and spacecraft are resupplied, maintained, upgraded and, if necessary, repaired; a transportation node from which payloads and vehicles are launched to their destinations; an assembly facility where, with ample time on orbit and the presence of appropriate equipment, large structures can be put together and checked out; a manufacturing facility where human resourcefulness and the servicing capability of the station combine to enhance commercial opportunities in space; a storage depot where payloads and parts are kept on orbit for subsequent deployment; and, consistent with the longer range thinking which is taking place both in this Nation and abroad, a staging base for future endeavors in space.

The space station will also be a highly visible yet peaceful demonstration of U.S. leadership, as we join with our friends abroad in a striking example of free world unity and capabilities. During the past year, we have begun a number of activities that are central to understanding the Space Station Program upon which we have embarked. A complex, technical effort of space station definition and preliminary design, phase B, has been initiated with U.S. industry.

Phase B studies are scheduled to begin formally in April of this year. Central to the detailed definition phase of the program, they will, in combination with an accompanying technology program, provide NASA, the administration and Congress with the necessary data upon which to scope the hardware development program.

The phase B analyses will incorporate the man-tended studies that Congress directed us to conduct. Our contractors understand the importance we place upon these studies and are prepared to carefully consider this approach.

The phase B analyses will be keyed to the user requirements that we have studied extensively over the past 2½ years. These requirements are a primary driver of space station design. They will be refined and updated throughout the life of the program.

Concurrently, with this emphasis upon user requirements and the phase B definition and preliminary design studies, we have initiated a major program of technology development.

This part of the definition program is a vital and necessary accompaniment to the systems studies in order to assure the availability of necessary technology that will be required by the space station.

To implement these and the other activities of the Space Station Program, we have established a management structure which, as the subcommittee knows, features a three-tiered allocation of responsibility.

Level A, here at NASA Headquarters in Washington, is responsible for the policy and the overall direction of the program. Level B, located at the Johnson Space Center in Houston, is responsible for program management and the technical content of the program. Level B is also responsible for integrating the work of the five level C centers which are responsible for discrete project elements.

Our program plan envisions a 21-month phase B definition and preliminary design effort with the hardware development phase, or phase C/D, beginning in fiscal year 1987. Early in 1986, we will conduct a series of technical reviews that will result in the definition of a space station baseline configuration to which the rest of the phase B emphases will be applied. At the end of the phase B activity, scheduled for early in 1987, we will begin the competition for phase C/D.

This program plan assumes a strong role for NASA in program management and provides genuine competition among U.S. industry. It is compatible with meaningful international participation in the Space Station Program. It gives a strong voice to the space station user communities and establishes a significant effort in technology development.

Most importantly, the Space Station Program plan will be based on a detailed definition that is, in my view, the only way we can assure credible cost, schedule, and technical projections.

And finally, it is a plan that will enable NASA to meet the goal set by the President of developing America's permanently manned space station within a decade. We are here this afternoon to ask your support of it and for the resources necessary in fiscal year 1986 to move the program forward.

Our budget request for fiscal year 1986 is $230 million. Of this amount, $15 million is for utilization, $82 million is for advanced development, $52 million is for program management/integration, $7 million is for operational readiness—this is a new budgetline this fiscal year—and $74 million is for the system definition contracts. Attached (fig. 1) to my written statement is a chart that summarizes this request and shows funding for previous years.

[The prepared statement of Mr. Culbertson follows:]

Statement of

Philip E. Culbertson
Associate Administrator
Office of Space Station
National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

Last year President Reagan directed NASA to develop a permanently-manned Space Station and to do so within a decade. Congress endorsed this initiative by providing the authority and funds to begin the initial planning. The program's goal, shared by both Congress and the President, is to assure United States leadership in space during the decade of the 1990's and beyond. In response to these mandates, NASA has set in place a Space Station Program that is substantial in scope and ambitious in character.

This morning I would like to review the program with you, explain the FY 1986 Space Station budget request and continue with Congress the dialogue on Space Station that we in the Agency have found extremely helpful.

The Space Station Program is characterized by a number of key features. Let me highlight three of them at this point:

- Detailed Definition - an extensive period of Space Station definition is essential. We must have a thorough understanding of technical, cost and schedule parameters before proceeding to hardware development. This approach of minimizing risk through detailed definition was a principal recommendation of a major study on Project Management within NASA conducted in 1980 at the request of the full Committee;
- Customer Focus - the mission/payload requirements of the scientific, commercial and technology development communities that will utilize the diverse capabilities of the Space Station are paramount. We have incorporated them, and will continue to do so, in our technical planning and in our organizational arrangements;
- International Cooperation - President Reagan invited our friends and allies abroad to participate in the Space Station Program. The Space Station was on the agenda of the London

Economic Summit at which the Summit nations welcomed the U.S. invitation and acknowledged the benefits of such a program to technological and economic growth. Discussions with Europe, Canada and Japan have progressed significantly since we testified last year. I am confident that agreements on parallel definition and preliminary design activities will be concluded soon. Our potential international partners will assume the financial and technical responsibilities for any Space Station element they develop.

The Space Station is unlike any program NASA has undertaken, for it will be a permanent facility in space. No longer will we simply visit space. When the Space Station becomes operational we will be living and working in space around the clock, 365 days a year, well into the next century. The Space Station is also different because it is evolutionary in character. The initial baseline Space Station will have built-in the potential for phased, evolutionary development to meet future requirements.

This evolutionary character and the permanent nature of the Space Station make the undertaking truly unique. They place a new and difficult engineering challenge upon NASA and her industrial partners. But the rewards will be great, for the Space Station will significantly enhance United States capabilities to operate in space.

The Space Station will consist of a manned base and associated platforms, as well as collateral support equipment. Incorporating both manned and unmanned systems, the station will advance the technologies of automation and robotics. In response to a Congressional directive, we are carefully analyzing the potential for the extensive use of automation and robotics aboard the Space Station and for utilizing the Space Station as part of the national program to advance these technologies.

The Space Shuttle, whose capability for frequent and routine manned access to Earth orbit makes the very idea of a Space Station viable and attractive, will play a key role in Space Station development and operations. The Shuttle will carry the station elements into Space and help assemble them on orbit. It will be used as a test vehicle for the development of Space Station technologies. In conjunction with Spacelab, the Shuttle will provide valuable operational experience for the Space Station user communities. The Space Shuttle will, of course, be used for Space Station logistics and crew rotation once it becomes operational.

The Space Station will be a versatile and effective facility, serving a diverse range of functions. It will be:

- a national laboratory in space, for the conduct of science as well as the development of new technologies and related commercial products;
- a permanent observatory, to look down upon the Earth and out into the universe;
- a servicing facility where payloads and spacecraft are resupplied, maintained, upgraded and, if necessary, repaired;
- a transportation node where payloads and vehicles are stationed, processed and propelled to their destinations;

- an assembly facility where, due to ample time on orbit and the presence of appropriate equipment, large structures are put together and checked out;
- a manufacturing facility where human resourcefulness and the servicing capability of the Station combine to enhance commercial opportunities in space;
- a storage depot where payloads and parts are kept on orbit for subsequent deployment; and
- a staging base for future endeavors in space.

The Space Station will also be:

- a striking example of Free World unity and capabilities; and
- a highly visible yet peaceful demonstration of U.S. leadership.

During the past year NASA has set in place a number of activities that are central to understanding the Space Station Program upon which we've embarked. A complex, technical effort of Space Station definition and preliminary design, "Phase B", has been initiated with U.S. industry. Phase B studies are scheduled to begin formally on April 1st of this year. Central to the detailed definition phase of the program, they will provide NASA, the Administration and Congress with the necessary data upon which to scope the hardware development phase. The Phase B analysis will incorporate the man-tended studies that Congress directed us to conduct. Our contractors understand the importance we place upon these studies and will be directed to consider carefully this approach. The Phase B analysis will be keyed to the user requirements that we have studied extensively over the past 2-1/2 years. These requirements are a primary driver of Space Station design. They will be continuously refined and updated throughout the life of the program.

Concurrently, with this emphasis upon user or requirements and the Phase B definition and preliminary design studies, we have initiated a major program of technology development. Later on, I will discuss this in greater detail, but I want to say here that the development of advanced technological options for the Space Station is an activity of the highest priority, one to which we are devoting substantial resources. Within NASA we are working closely with the Office of Aeronautics and Space Technology to assure a balanced and effective technology program.

To implement these and the other activities of the Space Station Program, we have established a management structure which, as the Subcommittee knows, features a three-tiered allocation of responsibility. Level A here at NASA Headquarters in Washington is responsible for the policy and the overall direction of the program. Level B, located at the Johnson Space Center in Houston, is responsible for program management and the technical content of the program. Level B is also responsible for integrating the work of the Level C centers which are responsible for discrete project elements.

Our program plan envisions a 21 month (April 1985 - January 1987) Phase B definition and preliminary design effort with the hardware development phase, or "Phase C/D," beginning in FY 1987. This constitutes a slight adjustment to earlier plans that showed an 18 month Phase B. Early in 1986, we will conduct a series of technical reviews that will result in the definition of a Space Station baseline configuration to which the rest of the Phase B analysis will be directed. These reviews are major milestones in our definition program and will include U.S. industry as well as our potential international partners. At the end of the Phase B activity, scheduled for early in 1987, we will begin the competition for Phase C/D.

This program plan assumes a strong role for NASA in program management and provides genuine competition among U.S. industry. It is compatible with meaningful international participation in the Space Station Program. It gives a strong voice to the Space Station user communities and establishes a significant effort in technology development. Most importantly the Space Station program plan will be based on a detailed definition that is, in my view, the only way we can assure credible cost, schedule and technical projections. And finally, it is a plan that will enable NASA to meet the goal set by the President of developing America's permanently manned Space Station within a decade. I am here this morning to ask your support of it and for the resources necessary in FY 1986 to move the program forward.

Our budget request for FY 1986 is $230 million. Of this amount $15 million is for Utilization, $82 million is for Advanced Development, $52 million is for Program Management/Integration, $7 million is for Operational Readiness (this is a new budget line this fiscal year), and $74 million is for System Definition (Phase B contracts). Attached to my statement is a chart that summarizes this request and shows funding for previous years.

The following describes the major elements of our budget request and some of the consideration and criteria used in developing these requirements.

Utilization

In FY 1986, a total of $15 million is planned for the definition of Space Station utilization requirements. To fulfill our commitment to make the Space Station user friendly, we consider the requirements of the users to be the fundamental justification of the Space Station. Therefore, their needs establish the basis for the Space Station's capabilities. We have worked with and will continue to work with several hundred potential users, studying how their dozens of sometimes conflicting critical requirements will be accommodated by a Space Station that must serve many disciplines and many nations with pressurized modules, attached payloads and associated platforms, including at least one platform in polar-orbit. At present, these users have identified over 300 potential missions or payloads. When the priorities of the sponsors of these activities are considered, it is already clear that a large fraction of the proposals will require early accommodation aboard Space Station systems. These users are variously in the commercial sector; in the technology development community; and in the science and applications communities both national and international.

One of the major goals of NASA is to expand opportunities for U.S. private sector investment and involvement in civil space and space-related activities. The Utilization program has established an active and strong voice to reflect this goal within the Space Station Program and to seek out those commercial enterprises which might profit from using the Space Station. In this regard, we are cooperating with the NASA Office of Commercial Programs. We will also seek the advice and counsel of the NASA Advisory Council's Task Force on the Commercial Use of Space.

The emergence of the Space Station as a major NASA endeavor opens the potential for in-space research and technology development of much greater scope than in the past. Thus, system design criteria must be established to enable the Space Station to function as a research and technology facility. This is being accomplished in cooperation with NASA's Office of Aeronautics and Space Technology by considering special technology needs for end-of-the-century NASA missions and for the unique in-space capabilities that the Space Station will provide.

Space science activities and the civil operational applications, whether commercial or governmental, are developing into a strong set of demands on Station capability. We have made good progress already during FY 1985 in codifying the intentions of our potential foreign partners, and of other agencies, such as the National Oceanic and Atmospheric Administration. Within NASA, the Office of Space Science and Applications has developed a specific set of intended uses of the manned element and the associated platforms as part of its normal planning activities for the coming years. For example, the Office is planning for the proposed Earth Observing System (EOS), a collection of instruments and sensors for the Space Station polar platform which will observe critical parameters of the Earth and its environment.

As part of the Agency's continuous effort to involve the users in all phases of Space Station design, development, and construction, NASA established the Task Force on Scientific Uses of the Space Station, chaired by Dr. Peter Banks of Stanford University, The Task Force is a derivative of the NASA Advisory Council's Space and Earth Science Advisory Committee. Its membership includes scientists representing all of the major disciplines, i.e., astronomy, astrophysics, life sciences, planetary exploration, earth observations, microgravity science and information systems. Its responsibility is to counsel NASA on plans for, and work in progress on, the scientific utilization of new capabilities that will be afforded by the Space Station. The Task Force has met several times and has presented a number of strongly argued recommendations. A report on its week-long summer study last August is in final preparation. Although NASA may not be able to act on all the recommendations of the Task Force, the group has been extremely effective and will continue to be of great value to the program.

We also seek advice from the Space Science Board. The Board is an activity of the National Research Council of the National Academy of Science and the National Academy of Engineering and serves as their focus of interest and responsibility in space science. It is conducting a special, two-year study of scientific use of the Space Station in the late 1990's and beyond.

Our Space Station utilization effort is critical for the coming fiscal year to get the design effort started in the right direction. In FY 1985, we are emphasizing the top level functional requirements that will shape the Phase B definition and preliminary design activity. In FY 1986, the interplay between users and the Space Station definition effort will be refined as we start the process of determining how to accommodate each of the user's specific requirements. We will also start the process of determining ways of extending the life of specific space assets by the use of the Space Station for servicing.

Servicing, in fact, will be one of the most valuable capabilities of the initial Space Station. The Hubble Space Telescope, for example, could be refurbished and serviced at the station avoiding a costly return to Earth. Other proposed projects such as the Advanced X-Ray Astrophysics Facility (AXAF) and the Gamma Ray Observatory (GRO) may also be refurbished and serviced at the Space Station. We will continue to study what specific servicing can best be conducted from the Space Station and to what extent robotics can be used to enhance the effectiveness of EVA crew hours.

The major area of expansion in utilization activities in FY 1986 will be in the development of mechanisms to provide consistent and user-friendly interfaces throughout the user's experience with the Station. These will include easy access to arrange for providing services, provisioning, replenishment of consummables, and the retrieval of products, including both scientific and technical data. In keeping with the recommendation of the Banks committee, we will place special emphasis on user information systems that will accommodate a broad spectrum of users.

Commercial Participation

We have established several roles for potential private investment and involvement in the Space Station Program. The private sector could participate as a builder, operator or a user. A builder would participate in the definition and development programs and contribute to the capabilities of the Space Station. An operator would support the program in the operational phase. A user would define missions and utilize the Space Station's capabilities.

Since 1982, our principal activity regarding commercial participation has been with users. Although there has been some private sector interest in a builder role for free-flying platforms these are not formally part of the Space Station Program. However, we believe there can be a role for the private sector in building, with private capital, elements of the Space Station. We plan to better understand what might be done to encourage such commercial participation. In this, we will work closely with the NASA Office of Commercial Programs in order to assure that we do not establish precedents that could adversely affect the private sector's future in space. Any policy established must enable the evolution of a free, competitive marketplace.

Advanced Development

The Advanced Development Program is intended to provide technology design options for the Space Station. Within this program, selected high leverage generic technologies are focused for Space Station and are matured to a prototype level in order to demonstrate their feasibility, establish their performance, and quantify the risks (cost and schedule) associated with their potential introduction into the Space Station development effort. This selection and focusing process for technology options is being performed in cooperation with the Office of Aeronautics and Space Technology and is built upon a generic base of space technology developed by that office. This program has been initiated in FY 1985 and will be continued throughout the definition phase so that we can be sure of the technologies that we determine to be appropriate to carry into system development. In FY 1986, a total of $82 million is planned to turn these concepts into prototype hardware and to conduct the necessary tests and evaluation. To accomplish this, NASA has established a series of technology test beds at our field centers to quantify and validate the performance of advanced components and subsystems in a ground laboratory environment. Evaluation and testing of some of these technologies has already been initiated in a number of major discipline areas including: attitude control and stabilization, power, thermal, environmental control and life support, auxiliary propulsion, data management, structures and mechanisms.

In FY 1985, the test beds were put in place to evaluate the more mature elements of technology through early tests of brassboard type hardware. In FY 1986, the test beds will be expanded to accommodate additional brassboard tests as well as testing of prototype level hardware and system evaluation.

During FY 1986 we will continue, in cooperation with other NASA program offices, the development of several Shuttle based flight experiments in areas that are not only important to early development of technology for the initial Space Station but also have application to other space activities and which require testing in the space environment. Experiments planned for Shuttle flights in 1986 include the verification of high power solar array technology, the measurement of atomic oxygen effects on materials, the testing of two-phase thermal pump and radiator systems, and the demonstration of erectable structural systems. As the test bed activities identify promising technologies that need to be tested on-orbit, other flight experiments will be carried out to support the development program.

Program Management/Integration

The major components of our $52 million request for Program Management and Integration are the System Engineering and Integration (SE&I) effort and the Technical and Management Information System (TMIS). SE&I for the Space Station Program is intended to be primarily a NASA in-house effort with support from industry for some specialized technical studies and for certain administrative support tasks. The TMIS is a program wide information system with the basic objectives of improving the productivity of individuals and facilitating program integration tasks.

The FY 1985 SE&I effort is focused at preparing for the beginning of the definition and preliminary design effort. A Systems Engineering and Integration organization has been established at Level B, and organizational relationships between Levels B and C are being established. Analytical tools are being developed and special studies are underway leading to subsystems design requirements. Technical panels are being instituted to coordinate discipline oriented output of trade studies, an engineering master schedule is being developed to orchestrate the design process, and a data base is being constructed for the exchange of technical details.

In merging both the technical and managerial requirements into a single system, the TMIS becomes the backbone of communication, coordination, and information transfer. TMIS is essential to undertaking and completing systems engineering and integration, and it is the fundamental instrument for gathering, transmitting, analyzing, and presenting the information employed in program management. We have initiated incremental development of the system that is consistent with our program phasing.

System Definition

Our definition phase contracted efforts get underway this coming April. The Space Station Program will begin a 21 month period during which engineering information will grow in detail as our options are focused to a single design. Throughout this process, contractor teams in support of each work package will be working to conduct trade studies examining a variety of options for the Space Station design. In mid FY 1986, as an outcome of the Systems Requirement Review, we will select a Space Station baseline configuration. Subsequent to this, preliminary design of the Space Station will commence and extend into the first quarter of FY 1987. These contractor studies will be managed by Level C centers while Level B will have the principal responsibility for tying them together to produce a single integrated system design. The FY 1986 funding increment requested for this system definition effort is $74 million.

Two special topics are being addressed as part of the Phase B definition and preliminary design analysis--the man tended approach and the subject of automation and robotics. Both topics are of particular Congressional interest. The question of how the permanently manned feature of the Space Station can be phased in over a period of three to five years will be worked in all facets of the definition. We will report back to Congress on the man-tended approach, as required by law. The automation and robotics plan, which will be presented to Congress by April 1, 1985, will outline an approach to incorporate appropriate advanced technologies in the Space Station. This plan will be given to the Phase B contractors and be utilized in their activities.

Operational Readiness

In FY 1986 we are requesting $7 million for Operational Readiness. The operations activities are directed to insuring the readiness of the Space Station Program to conduct a continuum of scientific, technological, and commercial missions. The Space Station represents a new opportunity to develop space operations as an ongoing, routine activity with the flexibility to take full advantages of new technologies and scientific discoveries as they surely will occur. The program will draw both on industry for detailed ground and space systems design and upon NASA's long and broad experience in manned and unmanned operations to develop the overall operation concepts.

Operationally, the Space Station Program differs from previous NASA programs in several aspects. First is the necessity to routinely integrate Space Station and payload systems on orbit, rather than on the ground prior to flight, in order to support a wide range of varying and different missions. New techniques will be required to verify electrical and mechanical interfaces and functional relationships where one part of the hardware is on orbit and its component piece of hardware is being developed on the ground.

Additionally, we must develop a logistic system that periodically provides the Space Station with consummables, spare parts, payloads and people. The logistic system must also support the provisioning for the platforms on a regular basis.

In FY 1985 we are developing operating concepts for the launch, orbital, and logistics systems. Our in-house effort to date has resulted in preliminary operational requirements and plans. These will be incorporated in the Phase B studies. These requirements and plans scope the ground based facilities requirements and systems design, and Space Station system operational characteristics. Contractor analysis and NASA studies are being used to complete the overall Space Station operations concept that will take full advantage of NASA's expertise and institutional base. The operational concept must include mechanisms for international operations. A multinational Operational Concept Working Group will be established to coordinate operational and planning studies.

In FY 1986 the operational requirements will be established and preliminary design and definition studies will be initiated for the various ground systems that support the Space Station operations. These studies will develop systems requirements for our prelaunch, orbital, logistics, and payload operational activities. They will be closely coupled with the Space Station Phase B studies. The results of these operational studies and the Phase B analysis will be integrated by NASA's operational staff at Level B and will lead to the preliminary design and definition of the ground operation system. This is expected to be completed by the start of Phase C/D in FY 1987.

Program Organization and Management

Mr. Chairman, as you know, in response to the President's directive to establish, within a decade, a permanently manned Space Station, the NASA Administrator established the Office of Space Station to implement the program. This is the first opportunity we've had, as a program office, to present testimony to you. As I mentioned earlier in my statement, we have established a three-tiered allocation of responsibility to manage the Space Station Program. Neil Hutchinson, the Space Station Program Manager for Level B at the Johnson Space Center, is sitting beside me and he will address the organization and activity at Level B.

Let me comment briefly on Level A. The Level A Space Station Office is responsible for providing overall program direction and top-level requirements definition. It is also responsible for technical, budgetary, schedule and cost controls as well as operations planning, advanced systems and strategic planning, top-level engineering oversight and international and commercial policies and plans. We have set out an organizational structure for Level A which is shown in the chart attached to my statement. The Office is now almost completely staffed and I am delighted to say we have a first-rate team on board.

The total approach to Space Station management was detailed in a report provided at your request entitled "Space Station Management Plan and Procurement Strategy." The report was delivered to the Committee in December 1984. In addition to extensive organizational and managerial material, the report contains a discussion of the procurement strategies and the rationale for the method selected for implementation.

International Activities

Mr. Chairman, let me conclude this statement with some comments about the international dimensions of the Space Station Program.

President Reagan's Space Station charge to NASA also included a call to friends and allies of the United States to participate in the program to "strengthen peace, build prosperity and expand freedom for all who share our goals." The President reaffirmed this invitation at the London Economic Summit where he explained the Space Station Program to the leaders of the participating countries.

As we testified last year, the potential of international cooperation in the program has been a primary planning criteria from the outset, and in the 1982-1983 time frame we encouraged potential partners to perform their own mission analysis activities. Such analysis activities were undertaken in Canada, Europe, and Japan. The results have been exchanged and updated in a continuing series of workshops. All inputs, including ours, are now being updated prior to the initiation of definition studies. The commitment to long-term utilization of Space Station capabilities is a primarily guideline for international partnership in the program. The NASA reference configuration developed as a point of departure of our definition studies has been shared with potential partners and each has been specifically requested to inform NASA of the reference configuration(s) which they currently envision for the elements which they will analyze in their own Phase B studies.

In order to further coordinate predefinition activities and share status information, additional workshops were held in Washington, D.C., last year at which preliminary guidelines for international cooperation in the program were presented by NASA and discussed with officials from ESA, Great Britain, France, Germany, Italy, Canada, and Japan. At the last workshop, a proposed set of technical guidelines for the program was also presented and discussed. These will be discussed further and evolve as we proceed. At each of the workshops a major theme has been the necessity to coordinate Phase B studies on compatible schedules in order that information will be available on all elements of the initial Space Station at the time it is baselined early next year.

The guidelines for international cooperation in the Space Station Program are based upon those successfully followed in more than 25 years of cooperative international activities. The unique, long-term nature of the

Space Station Program, however, has given rise to several significant criteria. Reference has already been made to the requirement that international partners have long-term requirements to utilize Space Station capabilities. The fact that this program will span several decades dictates that a true partnership must incorporate on all sides a commitment to utilize the Station. It is envisioned that the ownership and responsibility for sustaining engineering of internationally provided elements will rest primarily with the international partner.

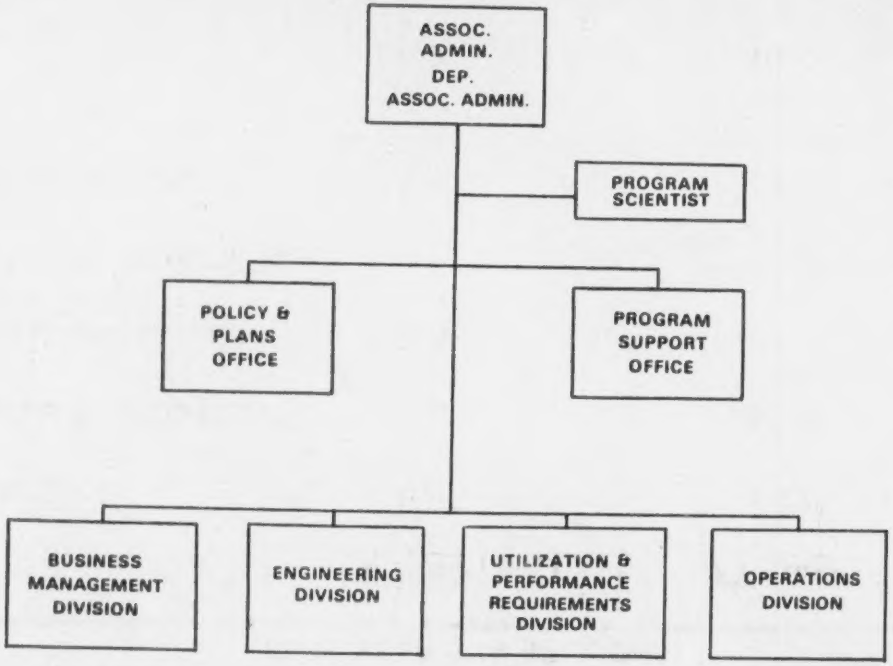
Agreement in the form of Memoranda of Understanding (MOU) to coordinate activities during Phase B are currently being negotiated. They will set the framework for cooperation during this phase. In addition, they will establish a process to identify elements for the initial Space Station which could be developed by international partners. The financial and technical responsibility for the international components of both Phase B and Phase C/D rests with the participating countries.

I can report, at this time, that a number of Space Station elements are under consideration by potential partners as candidates for international development. The ESA Space Station Program declaration includes the study of pressurized modules, unmanned payload carriers with resource modules, and ground support facilities. Canada has reported its intention to study construction and servicing facilities, solar arrays, and remote sensing facilities. Japan is studying the concept of a multi-purpose experiment module. Each of these potential investments, if realized, would add significantly to the capabilities of the Space Station. And they could lay the basis for long-term, mutually beneficial partnerships in the Space Station Program.

Conclusion

We have embarked upon a new challenge that will enable the United States to achieve a new level of capability in space. The Space Station will provide a permanent human presence in orbit around the Earth. It will be a truly versatile facility, one that will expand the frontiers of knowledge, push the development of technology and stimulate commercial enterprises in space. The Space Station will demonstrate to the world our intention to remain the leading nation in space while, at the same time, promoting international cooperation with our friends and allies. President Reagan's directive has set NASA on a course to meet that challenge. We have begun the task. With the continued support of Congress we will be able to make significant progress this year and in the years ahead.

OFFICE OF SPACE STATION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PROGRAM SUPPORT OFFICE
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ENGINEERING DIVISION
UTILIZATION & PERFORMANCE REQUIREMENTS DIVISION
OPERATIONS DIVISION

NASA HQ S84-1986 (1)
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OFFICE OF SPACE STATION
FY 1986 CONGRESSIONAL BUDGET
INITIAL DEFINITION
(REAL YEAR $ IN MILLIONS)

	FY 1984	FY 1985	FY 1986
UTILIZATION	4.1	9.0	15.0
ADVANCED DEVELOPMENT	6.9	52.3	82.0
PROGRAM MANAGEMENT/ INTEGRATION	5.4	33.7	52.0
OPERATIONAL READINESS	--	3.0	7.0
SYSTEM DEFINITION	5.5	52.0	74.0
TOTAL	21.9*	150.0	230.0

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* Funded as part of the Office of Space Flight ($13.0 million), Office of Aeronautics and Space Technology ($6.0 million), Office of Space Science and Applications ($2.0 million), and Office of Space Tracking and Data Systems ($0.9 million).

Mr. **Culbertson**. Mr. Chairman, I would like to stop at this point and turn the microphone over to Mr. Hutchinson, who will take it and describe the program from the management point, or level B (fig. 2.)

Mr. **Hutchinson**. Thank you, Mr. Chairman. It is indeed a privilege for me to be here today representing the NASA Field Center Team that we have assembled working on the Space Station Program. I watched this process from afar for a long time, so it is a particular privilege to be on this side working on a program that is as important to our future as the space station is. I hope I can give you some insight into our organization and its accomplishments since John and I joined the team last spring and our plans for the rest of fiscal year 1986.

The Johnson Space Center was designated the lead center last spring, in February, by the Administrator. And, in a nutshell, our job is to manage and integrate and coagulate back together the technical content of this program. We also manage the program funds at level B to guidelines that are provided us by the NASA headquarters level A people. We assure that the operations and customers activities are integrated into the program into a continuum, and those operations and customer considerations are a basic part of the design process for the program.

We also, of course—Phil mentioned the international element. We have been involved in the integration of that element back into the program, as well.

Our first task last April, when we came on board was to transition this activity from the Space Station Task Force at NASA headquarters to level B and level C at the Johnson Space Center and the level C's around the rest of the agency. The approach was to gather a group of people agencywide. And, we got 200 folks from all over the agency, level C, the rest of the field centers, jet propulsion, and brought them into Houston, brought them there. The "Skunk Works" was a miniature of the current agencywide space station organization and proved, in retrospect, to be a great team builder, because we got a lot of the principles established during that activity that we are now operating under.

I would like to discuss a couple of the primary tasks that that team took, one of them being the space station reference configuation that you see before you here in the model. About half the people of those 200 folks worked on a thing we call SE&I. And, you will hear that, systems engineering and integration, and what that really is is the activity that the agency has taken on in lieu of a prime contractor to bring these various elements of the space station back together into a coherent ship.

We started last year with six space station configurations and you will note that the one you see here is probably not the one that you recall that was floating around these falls and other places that the President used to explain the program when it first came online last year.

During, the summer, we completed two complete design cycles on the space station, starting with six, narrowing to three, and finally to what we call a family characterized by articulated solar rays, the rays that move.

The power tower is the representative of that family that we have chosen to start the definition phase with. Now, let's see, I wonder, could we show the slide?

I would rather use the slide; however, I can use the model to show you just as well.

The space station, the power tower configuration, is characterized by the articulated solar rays here, about 400 feet long from end to end. This structure, the spidery structure, is made from a series of 9-foot box tresses that fold up into little tiny packages and are pullied. We take the station up in parts, and I have got a film we will show to discuss that a little bit. The rays that you see here are in the configuration of the initial station, about 75 kilowatts worth of solar power, enough to power 15 or so average family houses. At the bottom of the configuration are five modules where the crew lives and works, two are laboratories, two are what we call habitation modules, one which is active and one is a module we sleep in; and, the fifth one is the one that is carried back and forth, the logistics module, back and forth in the shuttle each time we come up and back.

The things that really drove us to choosing this configuration are centered around the way it flies. It flies around the Earth with this end down all the time. And, the reason it does that is because of the small differential gravity forces spread out along this structure, it will orient itself to go around the Earth at this end, pointed at the earth at all times. This allows this set of instruments to always have a clear 360-degree view of the celestial sphere, and down at the bottom, we have a 360-degree view of the Earth, the full orbital revolution all the time as the station flies around, so primarily driven by viewing requirements this station provides a remarkable viewing capability that many of the other space stations don't have. The orbiter attached here at the bottom of the station has a clear approach path, not in the way of the major structures that are appended. There is a lot of framework on here on which we can mount things.

Another thing that is an attribute the configuration has, it grows very easily, out this way, add solar panels, grow it up this way and out this way to add instruments and all the time you add things and change the mass; it doesn't change the basic flying characteristics of the station.

We have a tendency—it is the first model I have ever seen of it, probably the only model in existence that I know of, although I heard there was one at the Kennedy Center.

It probably won't look the same next year when we come back and explain exactly what the station looks like. We are just starting the definition phase and we needed a single starting point to take off from, and the power tower is it.

While we were working on defining the reference configuration, we also worked on a parallel effort to define work packages and work packages is a method whereby we partitioned the configuration for project management and contracting purposes into several individual entities.

The idea was we wanted to provide a framework to maximize the center expertise we could bring to bear on the program, the NASA field center expertise, and the program was too big to operate from a single field center, and we had a great desire not to get a single contractor in a position where he was building the entire structure for us, so we worked on the work package plan and in the "skunk works," and we devised a system which is outlined in my written testimony, four work packages, one each to the Marshall, Johnson Center has a package, the Lewis Research Center has a package, and the Goddard Space Center in Greenbelt, MD, has one.

These four packages comprise the basic entity that you see there assembled together in a space station and a detailed explanation of those is in my written testimony.

After we finished the definition of the work packages and configuration defined, we set about to write the request for proposal from which we are proceeding to acquire our contractors for the phase B effort. It uses the reference configuration, each one is a contracting entity. It is 21 months in length, fixed price contracts. We hope to get two contractors on each one of the work packages to maintain competition during phase B.

The PFR was released on September 15, and 2 months later, November 15, we received 15 proposals at the Johnson Center, against that RFP. Ten of those proposals are still in the competitive range at best and finances are under evaluation right now. We expect to complete our factfinding for the Administrator about mid-March and hope to have the contractors selected and be on contract operating against the reference configuration about April 1.

Another "skunk works" task, of course, was the budget activity that we are here today to talk about. And, let me spend some time talking about three very key elements of that budget.

Definition preliminary design to phase B contracts is one of the elements, continued refinement of our customer activities, and third is advanced development program Phil spoke of.

Our advanced development program is a parallel effort. It is about equally funded in both 1985 and 1986 and certainly is equally important.

The advanced development activity focuses on the IOC station, the idea being that the agency wants to take the technology base that we have and look at particular problems that are worrisome on the technology problems that are worrisome on the station or can provide us an enhancement in performance and concentrate on those by actually building pieces of hardware to then take into a laboratory, a test bed on the grounds or a test bed in the area, namely the shuttle, try them out and make sure we understand how they work and can characterize their performance and understand what they can and can't do with regard to operating on the space station.

This entire process, we think, will lower our risk when we get to the hardware development phase because we will have a great deal more knowledge about the specific equipment we are going to build. We have 200 small contracts in work supporting that advanced development program as opposed to the eight contracts we hope to have on the primary phase B definition of preliminary design.

In 1985, we are acquiring those contractors with half on board right now. We will be building up the seven test beds that I mentioned, and certainly we will begin analysis and design of the hardware. In 1986, we concentrate on building the hardware and testing it in the test beds and folding those results back into the phase B program.

Along with the advanced development, we have got a significant activity in level B at the Johnson Space Center, as is the case in the level A in the customer world. We have a primary organizational element in my organization by the name of the Customer Integration Office. They have an advocacy role in this engineering effort in that they are representing the customers' world to the space station designers, of equal stature to the engineering organization, and I really believe that we are going to as great a means as we can to make sure that the agency, level A, B, and C people understand what people want, so when we get it built, we will have something people can use.

I have a program scientist on my staff, Dr. Owen Garriott, has flown on the STS once and is scheduled to fly again, also a member of the Peter Banks Task Force on Scientific Uses of Space Stations, and is certainly an able customer advocate at the level B.

In fiscal year 1985 and 1986, our budget supports all fronts in the utilization area. We have numerous small contracts out in utilization working on attach payloads, laboratories, platforms, and the servicing activities. We have a small outreach program operated by the level A customer office, to gather data from nonaerospace industry participants. This whole effort is aimed at understanding your customer so we can build the proper facility for those folks' use.

The third major activity which is the focal point of our program over the next year and a half is the definition and preliminary design. The level C centers and their contractors, eight contractors we are about to acquire, are going to be managed by the level C centers and provide the cornerstone of this effort.

My job at level B is to take the results of that effort and integrate it back into a coherent space station and hopefully produce a properly controlled and effective convergence of all of those studies into a station by the middle of next year.

We are going to start from the reference that you see there, and unfortunately, we don't have a model yet of the platform, but we also have a reference of the attendant platforms, the polar and near orbiting platform. And, the job of this phase B activity is to turn that reference into a baseline, and in 1986 to take that baseline to a preliminary design over a period of about 21 months.

We will be testing against a better and better designed requirement base. And, another point that needs to be made in that regard is the international activity. The international people will be operating phase B studies in parallel with the NASA effort and integrating them along with the four field centers that we are integrating on the U.S. side of the house, so by about the contract midpoint, we should understand the entire configuration.

Before I leave the definition of preliminary design and activity, let me discuss one more characteristic and that is the robotics and automation. This Congress is interested in that, and I can tell you that the Agency is interested in it. We have got a lot of emphasis in the request for proposal on automation and robotics and have a committee that has been studying it.

Their efforts are to be brought forth to you in about a month. The advanced development program has a good emphasis on automation and robotics. We can't even put the space station together there without a significant advance in that field.

I brought with me today a film that some of you have seen that was put together at the Johnson Space Center. It is an assembly scenario that was used to check the remote manipulator, on the shuttle. And, the little one you see on a track down underneath the configuration there in the middle to check the kinomatics and the reach of these manipulators because they are key to us being able to assemble a station.

It depicts a seven-flight assembly sequence, seven flights of the shuttle to put together what you see there, and if I could have the film quickly, we will have a look at this sequence.

[Film presentation.]

Mr. HUTCHINSON. I think we have now an organization in place and the processes designed to conduct the definition phase. I think we have got a well-thought-out starting point, and I want to emphasize it is only a starting point, because it is going to be changing nature and we will soon acquire the industry teams. And, we have a carefully planned and well-thought-out advanced development effort to work on subsystems technology where appropriate, and the mechanisms to understand our users. And we know how to feed that understanding back into this design, and we have folded the man-tended activities into the phase B definition and we have a good program in automation and robotics.

And last, although this prime contractor role that the Agency has taken on is a difficult one, I believe it is a challenge we will step up to and do a great job on. And, we are ready to go do it.

With the 1985 and 1986 effort that this budget supports, I believe we can approach the hardware development phase with confidence and inform the technical constituents of what we want to build. And I think we will have a good handle on how much it is going to cost.

[The prepared statement of Mr. Hutchinson follows:]

Statement of

Neil B. Hutchinson
Manager

and

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Space Station Program
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

We consider it an honor and a privilege to be here today to represent the fine NASA field center team now working on the Space Station. We hope to give you some insight into the past year's accomplishments and a status of our activities and plans for the remainder of FY 1985 and FY 1986. Since Mr. Aaron and I were assigned last April, I believe the team has continued to make significant progress in several key areas. Among them are further definition of the needs and uses of a permanently manned space station and man-tended platforms, definition of a reference configuration, identification of work packages and their assignment to participating Level C NASA centers, initiation of the industry acquisition process to get the Phase B definition and preliminary design phase underway, initiation of advanced development work in key technologies, and structuring and staffing organizations at both Levels B and C to carry out the Program. These accomplishments were made possible through the efforts of a highly competent and dedicated team of NASA, industry and scientific community personnel.

Level B Functions and Activities

In February of last year, the Johnson Space Center was given "Lead Center" responsibility by the NASA Administrator to carry out the following five basic responsibilities:

- Systems engineering and integration - Establish and manage the technical content of the Space Station Program, in response to the system requirements established by Level A.
- Business management - Manage the Program resources to the budget and schedule guidelines provided by Level A.

- o Operations integration - Assure that Space Station operations considerations are properly incorporated in the derivation of requirements and design of the system.
- o Customer integration - Manage the integration of customer requirements to assure customer needs are a pervading program influence.
- o Support of Level A - Provide overall support to Level A during budget and schedule formulation, establishment of system requirements and other aspects of program direction.

In order to initiate these Level B functions it was necessary to transfer the day-to-day program implementation from the Space Station Task Force at NASA Headquarters to the Johnson Space Center (JSC) and the participating Level C centers. This included defining tentative Level C responsibilities and then producing the Phase B definition and preliminary design request for proposal (RFP) including a work package structure that matched the Center responsibilities. In addition, it was necessary to produce a Space Station program plan, organize and staff the Level B and C Program and Project Offices, and define the detailed content of the annual operating plan.

The transition approach was to gather talent NASA-wide and co-locate them for about 6 months at JSC. For continuity of experience and needed expertise, people from the Space Station Task Force were included, as well as personnel from the field centers who had been supporting the Space Station Task Force. Over 200 scientists, engineers, and administrative personnel were assembled at an off-site facility near JSC designated the "Skunk Works".

The Skunk Works team undertook four major tasks: First was the continuing assessment and refinement of the user needs and requirements and the potential uses of the Space Station and platforms. Continued technical interchange and dialogue with user groups (such as the Task Force on Scientific Uses of the Space Station headed by Dr. Peter Banks) was conducted to iteratively arrive at the reference configuration and functional capability of the system. The result of that activity was an input to producing the Phase B RFP. The activity to refine the user requirements is an ongoing process in FY 1985 and FY 1986 and I will provide additional detail later in the testimony.

Second was to take the Space Station architectural concepts that had been studied by the Space Station Task Force and narrow the options to a reference configuration that met the user and system requirements, one that would serve as the point of departure for the definition and preliminary design phase, while also serving as the reference for the contractor acquisition process.

Third was to determine the best way to partition the work into logical packages that could be contracted to industry for analysis, definition and preliminary design, and that could be assigned to participating field centers for project management.

Fourth was preparation of an RFP for the definition and preliminary design effort. This document, which includes the statement of work for each of the work packages and the reference configuration was officially released on September 15, 1984.

I will briefly describe the content of each work package and the rationale for that content and associated center assignments.

Work Package Definition

The Space Station Program is comprised of various elements, including a manned base, man-tended space platforms and collateral supporting elements. The program elements and subsystems which comprise the total system have been divided into work packages for definition and preliminary design. This work package structure provides a framework for utilization of the knowledge, experience and capabilities of NASA's field centers. The assignment of specific work packages to field centers can provide for continuity between the preliminary design and subsequent phases because each work package center and its respective contractors may well be defining the subsystems to be delivered later.

In defining the work packages, we placed emphasis on logical and easy to work element-to-element interfaces. For example, to simplify the system integration process, the number of work packages was minimized and we emphasized that the subsystems and their parent elements be assigned to the same work package in so far as possible.

The manner in which the Phase B program elements and subsystems have been divided into work packages and center-assigned responsibilities is shown in figure 1. The Marshall Space Flight Center (MSFC) will be responsible for the common module, the environmental control and life support subsystem, propulsion subsystem, outfitting of laboratory and logistics modules, and accommodations for the Orbital Maneuvering Vehicle (OMV). The common module consists of the pressure vessel, secondary structural members, and utility distribution systems common to all pressurized modules. Common modules are then converted (outfitted) to modules for a specific use (i.e., habitat or laboratory) by installing equipment unique to their function.

MSFC's expertise in managing the development and integration of pressurized modules for Skylab and Spacelab and their experience with the production requirements for external tanks and solid rocket boosters for the Space Transportation System (STS) makes them well-suited to be responsible for multiple common modules. MSFC had previously been given responsibility for OMV development, and were thus the logical choice for assignment of OMV accommodation and servicing requirements. MSFC has developed significant logistics efforts to support the Space Shuttle main engine and solid rocket boosters which gives it an excellent background for the overall Space Station logistics analysis. In addition, MSFC has done the major laboratory outfitting for Spacelab, which is a fore-runner of the Space Station laboratory.

The Johnson Space Center will manage the overall Space Station assembly structure and closely related utilities and subsystems. These utilities and subsystems include manipulators and power subsystems articulation devices, thermal control subsystems, guidance, navigation, and control subsystems and the data management subsystems. This assignment matched well with JSC's expertise and capabilities in these areas and maintained proximity with the Level B organization. JSC has traditionally managed communications, EVA, airlock and habitability functions for manned space projects and has the appropriate personnel and facilities to continue in that capacity for the Space Station. In addition, since the STS program management is in Houston, it seemed appropriate to assign the Space Station interface requirements with the STS to JSC.

The Goddard Space Flight Center (GSFC) will be responsible during Phase B for platforms, attached payload accommodations, servicing requirements for platforms and free flyers, and outfitting one laboratory module. They have extensive experience in unmanned satellites and scientific payload integration activities as well as recent experience in repairing the Solar Maximum satellite which makes this assignment appropriate. In addition, GSFC will utilize its science and applications expertise in outfitting a common module as a scientific laboratory.

Finally, the Lewis Research Center (LeRC) was assigned Phase B responsibility to manage the electrical power system because of their extensive experience in power generation and distribution subsystems technology development.

These four work package centers will provide substantial support to the Level B systems engineering and integration (SE&I) function in their specific areas of expertise. In addition the other NASA centers (although not assigned a work package) will support the Space Station definition process: the Langley Research Center, the Jet Propulsion Laboratory, and the National Space Technology Laboratory for user and SE&I support; the Ames Research Center for manned systems support; and the Kennedy Space Center for support of prelaunch processing and logistics planning.

RFP Preparation

The RFP is based on the reference configuration for the initial operational capability of the Space Station and requires growth analysis to the year 2000 and beyond. It contains specific sections for each work package as well as significant overall Space Station attributes applicable to all work packages. We anticipate awarding one or more contracts for each Phase B work package. The contracts will be fixed price, with a 21-month period of performance. Some of the more important features of the document are:

- Potential bidders were asked to address both a continuously habitable and a phased man-tended approach to the Space Station requirement in accordance with Congressional direction. The contractor's analysis of delaying permanently manned habitation of the Space Station for three to five years following initial deployment is expected to utilize approximately ten percent of the definition effort funding during the period in which it is under study.

- Man-tended platforms for scientific applications will be an integral part of the Space Station Program and will have as much commonality with the manned base as possible.
- Recommendations of the NASA Advanced Technology Advisory Committee concerning automation and robotics advanced technologies are to be evaluated as an integral part of the Phase B effort.
- The Space Station's base and platforms capability for growth, customer responsiveness and friendliness, and maintainability on-orbit (to ensure indefinite life) are emphasized.
- Protoflighting, or the use of test hardware as flight articles, is specified wherever appropriate for achieving cost effectiveness.
- A rigorous design-to-cost approach is specified to assure that program requirements will be satisfied within stated cost targets.

Proposal Evaluation Status

A total of fifteen proposals was received in mid-November. Initial acceptability screening by the Source Evaluation Board reduced the number to eleven; three for each of the MSFC, JSC, and LeRC work packages, and two in response to the GSFC package. Then a NASA team began a detailed evaluation effort. We are still in the evaluation process, having completed the competitive range determination and oral discussions. Best and final offers are expected on February 8. Contractors selected by the NASA Administrator are scheduled to be announced in mid-March, and contract start is scheduled for the first of April.

The reference configuration is comprised of manned base and man-tended platforms elements. The manned base is referred to as the "power tower." The platform configuration takes advantage of being man-tended for servicing and emphasizes maintenance as well as potentially utilizing common subsystems from the manned base.

I would like to give a brief description of the reference Space Station configuration at this time in terms of its physical characteristics and attributes (see figures 2 & 3).

Power Tower and Platforms Description

The power tower configuration was selected because, of all the concepts examined, its natural attributes were best suited to the accommodation of user requirements. Since the long (over 400 feet) central tower is always oriented toward Earth and the articulated power generation system is located near one end of the tower, several challenging user requirements can be met. Earth viewing and solar/celestial viewing can occur simultaneously and continuously because the Earth-looking instruments are placed at the bottom end of the tower and solar/celestial viewing instruments are placed at the top. The power system is between these two locations and, as a result, does not obscure the view of either set of instruments.

Placing the solar celestial viewing instruments at the top of the tower also minimizes concerns about contamination of the instrument environments. Accommodation of tether experiments is simplified because the tower orientation and tether orientation both stay approximately constant with respect to the Earth. From the user servicing standpoint, the power tower configuration is attractive because the tower end away from the power generation system offers a large clear area for the approach and departure of supporting vehicles such as the Shuttle orbiter or OMV and their payloads. Payloads are removed at the lower end and transferred to the mobile remote manipulator for subsequent transfer to servicing or storage areas on the Station. The truss structure provides a convenient track for the manipulator as well as supplying a versatile storage area.

Finally, a very attractive feature of the power tower is its insensitivity to changes in the masses (additional modules, etc.) placed on the station. By using the small variation in the Earth's gravity along its length as a control force, the power tower inherently accounts for mass changes and therefore does not place tight constraints on the locations of payloads or the direction of growth. Insuring this versatility in payload manifesting and growth is a prime objective of the Space Station design effort.

The attributes and needs of the platforms were assessed in conjunction with the manned base assessment to arrive at an appropriate design approach. The capability to be serviced, maintained, and retrofitted at the manned base or in situ as appropriate, is a distinguishing feature of the reference platforms. We will continue to listen to the recommendations of user community groups (such as the Task Force on Scientific Uses of the Space Station) applicable to the platforms to determine such parameters as basic size and number as well as instrument accommodation needs. This continuing activity will aid in the assessment of the commonality potential of platforms subsystems with station subsystems.

FY 1985/FY 1986 Program Activities

Thus far I have described our activities over the past year. Now I would like to explain the major program activities that must be accomplished in the near term and in FY 1986 to continue system definition. These include advanced development, the definition and preliminary design effort, and continued definition of user and operations needs.

Advanced Development

In conjunction with the acquisition process to select Phase B contractors, we have initiated an equally important, and about equally funded, Space Station Advanced Development Program. This effort builds on the NASA's Office of Aeronautics and Space Technology (OAST) generic research and technology base by focusing portions of that base directly on Space Station needs. Technology candidates will be developed to breadboard, then prototype hardware status and subsequently operated in a test bed to obtain performance data. Over the past year, we have narrowed the scope, defined the content and priorities of key technology activities, and assigned responsibilities to NASA field centers having the necessary expertise to manage and conduct the effort. We are now processing about 200 small procurements agency-wide to initiate the effort. The near term objectives of the Advanced Development Program are to pursue subsystem technology design options for the initial Space Station that will enhance performance, effect lower operating costs, and establish a low risk Design, Development, Test and Evaluation (DDT&E) phase. Contractor acquisitions in support of these activities began in October 1984. The Advanced Development activities will continue throughout FY 1985, and major subsystems level test and evaluation using test beds and other NASA facilities will be conducted in FY 1986.

The Advanced Development Program today encompasses discrete tasks within nine technical disciplines including attitude control and stabilization, data management, auxiliary propulsion, environmental control and life support, structures and mechanisms, thermal management, electrical power, human productivity, and communications and tracking. These tasks are being conducted by all the NASA field centers and the Jet Propulsion Laboratory. The nature of the individual tasks ranges from the development of components and subsystems incorporating new technologies, to the operational support of component and system testing, to the analytical or physical integration and postflight assessment of Shuttle flight experiments.

NASA has also established seven technology test beds at various field centers to test and evaluate technology options and alternatives and quantify technology performance in a ground laboratory environment. Both advanced development and definition and preliminary design phase contractors will be encouraged to use these test beds, as well as other NASA facilities including STS flight opportunities to verify the technology and performance of components and subsystems.

Advances are being made in a broad range of endeavors across all nine discipline areas. A continuing objective in the Advanced Development Program is reducing (through the increased use of automation and artificial intelligence) the need for continuous crew and ground involvement thereby increasing both operational flexibility and responsiveness to users. I would like to report on the current status and planned progress of technology development by way of examples in four subsystems--electrical power, environmental control and life support, thermal control, and attitude control and stabilization.

Electrical Power

Providing adequate and affordable electrical power for both housekeeping and payloads is critical to the Space Station. One of the important objectives of the Advanced Development Program is to provide a potentially high payoff improvement to electrical power systems for space. Solar photovoltaic arrays and storage batteries are the current approach to long-term space power generation. However, for the anticipated baseline Space Station power requirements of 75 kilowatts (kw) with growth to 300kw, the solar arrays become very large (1/2 acre to 2 acres) and the batteries become very heavy (30,000 to 120,000 lbs.). This growth impacts Space Station weight, drag (reboost requirements), structures, control, and operations.

Solar Dynamic Power Systems (SDPS) offer significant potential improvement for Space Station needs. SDPS uses solar energy to heat a working fluid which then drives a turbine to generate electricity. Energy for the dark side of the orbit is stored directly as heat in a thermal storage device, providing a very efficient energy storage technique which allows the turbine to run continuously. SDPS offers the potential for greater overall efficiency and therefore reduced solar collection area (1/10 and 1/2 acre for 75 and 300kw respectively). The Advanced Development Program for the SDPS is focused on critical components such as the solar collectors and the heat receiver/ storage devices.

The advanced development tasks relative to solar arrays are designed to enhance existing technology and to improve efficiency and life capabilities. The tasks deal with improved silicon cell technology, protective coatings, and development of a long life, efficient regenerative fuel cell. The regenerative fuel cell is an alternative to the current battery technology for energy storage and offers a 6 to 1 weight reduction potential in addition to other technical advantages.

The remaining power systems advanced development tasks are associated with developing efficient, long life, low recurring cost and autonomous power management and distribution system hardware. Specific technology issues include high voltage AC and DC devices (200V to 400V), high power level (75 to 300kw) transmission and switching devices and automation techniques. These tasks will result in high efficiency, light weight, long life hardware capable of distributing and managing the electrical power required for operating the Space Station and supporting user needs without significant crew attention.

Environmental Control and Life Support

Development of new technologies for the environmental control and life support subsystem offers enormous potential savings in costs associated with supplying the basic commodities of air and water to the Space Station. For example, the present Shuttle orbiter environmental control and life support systems (ECLSS) are "open cycle", that is, the air and water resources are supplied from initial stores, and wastes are either dumped overboard or stored and brought back to Earth for disposal. Closing the life support cycle, by regenerating the atmosphere and recovering water used by the crew, can provide significant reductions in logistics resupply needed and in crew time spent on maintaining the systems. This new "regenerative" life support technology will have near term payoff and will become a continuing method of resource renewal.

Wastewater, such as from condensed atmospheric moisture, and from the shower, laundry, and dishwasher can be recovered for drinking and personal hygiene and can be electrolyzed to supply breathable oxygen. Deletion of water and oxygen resupply requirements alone can save 14,500 lbs. logistics resupply every 90 days. A Shuttle-type system to remove carbon dioxide (Co_2) from the air would require 4000 lbs. of lithium hydroxide canisters every 90 days. New regenerative CO_2 scrubbing processes could reduce this to a minimal weight, i.e., just the parts needed for system maintenance. Development of dishwashing and laundry equipment will allow dishes and clothing to be cleaned and re-used, thus saving storage space and significant resupply costs.

These regenerative processes have been under development for several years, to the extent that proof-of-concept has been demonstrated. In FY 1986, this technology development will continue for individual process subsystems. In addition, a program will be initiated to integrate all of the new technology subsystems into a ground-based ECLSS test bed to demonstrate the performance of these various processes as an integrated system. This integrated system will include atmospheric CO_2 removal and reduction, oxygen generation from water, water recovery from wastewater, and human waste management.

Thermal Control

The thermal control advanced development effort is focused on three specific areas: temperature and humidity control within the habitable module; waste heat collection and rejection from the Space Station and space platforms; and the heat transport and rejection for the power system options. The prime thrust is the development and application of two-phase fluid flow technology.

Past thermal control heat acquisition and transport systems using a single-phase liquid were heavy, required high pumping power and restricted system design and performance capabilities. Two-phase flow (i.e. liquid/gas) technology takes advantage of the increased heat transfer capability available from evaporation/condensation properties of fluids and since the fluid temperature is nearly constant, allows flexibility in the location and operation of payloads requiring thermal control. Two-phase flow technology offers greatly reduced pumping power requirements, reduced system weight and maintenance, and adapts easily to the changing demand of station operations.

Major efforts are also directed at development of efficient long life space constructible heat rejection radiators. Radiators which can be segmented, constructed on-orbit and which also exhibit minimal susceptibility to micrometeroid damage.

Attitude Control and Stabilization

The Space Station will be a large, lightweight and flexible structure (much more so than previous spacecraft) and thus its attitude control system must stabilize, control and accurately point the station and payloads in an operational environment more complex than previously experienced.

The attitude control system must control the station during the assembly phase, as additional modules and payloads are added during build-up and evolution, and during visits by the STS. To ensure that we can successfully stabilize and point the Station, technology development is underway in attitude control algorithm development, integrated control system analysis, automated performance monitoring, control moment gyro development and advanced sensor/effector components.

Control moment gyros, the primary apparatus for attitude control, were used in Skylab and various satellite systems. A control moment gyro test bed is under development and will be used to verify new attitude control algorithms and system approaches.

Definition and Preliminary Design Activities

Thus far, I have focused on preparatory efforts for Phase B contracted definition and preliminary design and I have discussed some examples of the Advanced Development Program problems and issues. I would now like to discuss the Phase B effort in terms of what must be accomplished in the remainder of FY 1985 and during FY 1986, and how we intend at Level B to conduct the overall task of integrating the Level B activities and the activities of the Level C field centers, their contractors, the results of the advanced technology efforts, the international elements and the user requirements activities together into a coherent Space Station design. In the course of this discussion I will explain how we are organized and the overall schedule framework for our efforts.

The Level B organization is shown in figure 4. At the staff level, in addition to the more traditional functions of procurement, legal, and safety, reliability, and quality assurance, we have established the International and External Affairs Office to serve as the focus for cooperative programs both domestically and internationally, a Technical and Management Information System (TMIS) Integration Office to ensure that the program has the latest technology available for communications and information transfer, and a Level B Program Scientist, Dr. Owen Garriott, to ensure an independent voice for the scientific community interests. As you are aware, Dr. Garriott is a scientist-astronaut who carried out extensive physical and life sciences experiments during his Skylab 3 flight, and who flew as a mission specialist on the highly successful Spacelab 1 mission, conducting a number of physical and life sciences experiments.

We have established four line organizations to implement the primary functions of the Level B Program Office. These offices will manage the functions of Systems Engineering and Integration, Data Management and Operations, Customer Integration, and Program Management.

To establish the framework for discussion of the Phase B effort, I have included the program schedule in figure 5. During the remainder of FY 1985 we will be concentrating on better understanding the user requirements and the definition of the Space Station baseline configuration, and in FY 1986 we will do a preliminary design of that baseline to give us confidence that we understand the technical risks, have a good basis for cost estimation and understand the required hardware development process and schedules. We will also during FY 1985 and FY 1986 focus our attention on automation and robotics, utilizing the report of the Advanced Technology Advisory Committee as a major input to our analysis.

Systems Engineering and Integration

The System Engineering and Integration team at Level B will have the primary responsibility for overall synthesis of the information being produced by the Level C work package and support centers, their respective contractors, the technology test beds and flight experiments that lead to configuration selection, interface definition, and the integration of the international elements. The SE&I task flow (simplified) is shown in figure 6. Let me briefly explain how we envision that this process will work to accomplish the complex task of system definition. The process begins with a time-phased set of user and mission requirements derived from the user requirements data base. These user requirements are used to derive system and operational requirements and their effect on the reference configuration. Within these requirements and configuration concepts, each of the work package centers and their contractors select candidate systems, subsystems and component approaches for trade studies and analyses. As discussed earlier, significant numbers of advanced development tasks have already been initialized by the centers. Results of these trades and development studies will be provided to Level B for synthesis into the overall configuration for cost analysis and technical capability assessment against the requirements. Through a design cycle such as described, an assessment can be made of the degree to which the design solution meets the requirements and cost guidelines within an acceptable level of technical risk. We plan to conduct three design cycles to achieve a baseline configuration definition by the Interface

Requirements Review (IRR). At three, six, and nine month points, we plan to make major configuration updates to reinitialize the reference configuration.

During each of the design iterations, we will incorporate the hardware elements being studied by the international partners and study the effect these elements have on the configuration in terms of additional demands for utilities and capabilities that are added to meet user needs. An International Technical and Integration Panel (ITIP) will serve as the interface with international partners for controlling the interchange of information to the evolving baseline configuration. The ITIP will ensure that changes initiated by either side will receive proper consideration and that partners have a mechanism for presenting their rationale and program impacts. Otherwise, the reference configurations for the international elements will be treated in a manner analogous to additional "work packages". A small adjustment in the timing of IRR and SRR will assist in synchronizing the international Phase B studies with the convergence process planned for the first half of the U.S. Phase B studies. We are optimistic at this point that the schedules can be harmonized.

During the first half of Phase B, we will evaluate a phased build-up to permanently-manned capability using a man-tended mode, as well as a permanently manned initial Station. The necessary analyses and trades will be performed to fully characterize the man-tended approach. NASA will submit the results of this study and those of the recommended reference configuration to the Congress for review prior to the selection by the NASA Administrator of a baseline configuration for the Space Station design and development phase.

In FY 1986, we will conduct the first major program review (IRR) aimed at making decisions on the interfaces between the various station and platform elements. During the interval between IRR and SRR, Level B SE&I, supported by the Level C centers and their contractors, will assess the results of the subsystem analyses and trade studies, the degree to which they meet the user and system requirements, and the maturity of technology development efforts in subsystems and components. This assessment activity is conducted to arrive at a clear definition of the interfaces between elements before proceeding into the preliminary design phase. Although this effort is more extensive than normal during a Phase B, we believe it is essential to have a mature technical understanding in order to reduce the risk of cost and schedule increases during the hardware development phase.

Following the SRR, the SE&I process will be even more rigorous in terms of configuration management and change control. Preliminary design effort will be focused to support the Interim System Review (ISR) where initial choices of subsystems will be made and additional specific analyses and trade-off studies will be defined to provide the necessary information base for subsystem selection at the System Design Review (SDR). Control of the process will be exercised through a structure of boards and panels that will guide the convergence and evolution of the system design to a point design configuration that will form the basis for the design and development (Phase C/D) RFP. The design and analysis efforts of the prime and subcontractor teams, and the technology development efforts on hardware and software to provide the optimum technology for subsystem decisions will be focused by the Level B SE&I organization and the supporting Level C SE&I teams to converge on a point design configuration at the SDR. The funding we are requesting in FY 1986 for the definition and preliminary design contracted effort and for the Advanced Development Program is essential to the accomplishment of this necessary task.

Although Phase B activities are primarily aimed at defining the baseline Space Station, a plan to meet the goals, objectives and performance requirements for possible evolutionary growth of the Station must also be developed by the end of the preliminary design phase to ensure that adequate provisions for growth have been incorporated into the initial Space Station design.

During FY 1986, Level B, in coordination with the Level C centers, will begin development of the Phase C/D requests for proposal. This will be an interactive process which will continue throughout Phase B activity.

We are also requesting funding in FY 1986 to continue implementation of a Technical and Management Information System which will use state-of-the-art, but off-the-shelf, computer software and communications technology to link the NASA field centers, NASA Headquarters and the prime contractor teams together for productive exchange of data and information at the technical interfaces. In addition, information on configuration and interfaces needed by international partners to conduct their definition and preliminary design activities will be provided by computerized data link. It is extremely important that this capability be provided in FY 1986 in order to be in place and operating for the Phase C/D design effort.

Customer Requirements Definition

In parallel with the activities I have described, an equally important activity is taking place in FY 1985 and FY 1986 to continue definition of the uses of a permanent space facility, and to understand the user/customer needs and requirements. As shown in the organization chart presented earlier, we have established a Customer Integration Office to manage these efforts at Level B. Since we do not know all of the potential uses of a space station in the decade of the 1990's, we are working both domestically and internationally with the scientific, technology development, and industrial communities, in conjunction with the Level A organization, to attempt to anticipate the capabilities that will be needed during this time period and beyond.

We are also working closely with NASA's Office of Space Science and Applications to understand and evaluate their future missions. It is apparent that there is great potential for cost saving through servicing and maintaining the instrumentation and systems of observatory-class facilities planned for the next decade. However, much work is necessary during FY 1986 to define servicing concepts and standards that can be implemented by both station designers as well as the user communities to turn these concepts into reality.

Another principal thrust in the Customer Utilization area during FY 1986 will be refinement of user engineering requirements in the area of specific laboratory, attached payload and platform accommodations to be provided by the Space Station and platforms. Emphasis will be placed on definition of growth requirements to acquire an understanding of impacts to the development of the initial Station.

Several committees and working groups within the Program are engaged in user integration activities. Advocacy groups under Level A and B co-chairmanship, and representing science, technology, and commercial interests, are actively pursuing definition of flight programs in these areas. Additionally, user groups are being established at the lead performing centers in specialized areas. For example, Goddard Space Flight Center has formed a Science Users Working Group to critique and review their design activity during the definition and preliminary design phase. Langley Research Center anticipates an analogous Users Group activity for technology development missions applied across the Program. Similarly, discussions with Marshall Space Flight Center indicate a potential need for such a group to critique their efforts at outfitting a materials processing laboratory.

The Program Scientist will work closely with the Customer Integration Office to assist in the interpretation of scientific requirements into engineering parameters that can be factored into the design cycles occurring in the SE&I process. It is important to understand that the design iterations are aimed at matching user needs with engineering capability and this process is appropriately an iterative one between the users and engineering to achieve a productive and efficient utilization of platform and manned base resources.

Operations Requirements Definition

A third area that we must incorporate into the definition and preliminary design process concerns the operational concepts that will be employed in order for the permanent facility to be easily resupplied, serviced and maintained indefinitely on-orbit. In FY 1986, we must study the use of advanced technology in automation, robotics, and artificial intelligence to take advantage of the greatly improved human productivity afforded by these capabilities. Because of the strong interrelationship between the on-board data management system and the operation of the Station, we have combined these functions into a Data Management and Operations Office at Level B.

Our experience in past manned spaceflight programs tells us that operational considerations must be factored into the design at an early phase. Therefore, we plan to complete in-depth studies of the ground operations, prelaunch flow, logistics concepts, on-board autonomy, communications, command and control concepts, and potential responsibilities of our international partners in station and platform operations in FY 1986. Although the funding request for operational readiness is relatively small, it is critical to the total system definition effort.

Conclusion

Phil Culbertson, at the end of his prepared statement, noted that we have embarked upon a new challenge that will enable the United States to achieve a new level of capability in space. We have made considerable progress so far in the program that will provide this capability and, with the support of the Congress, we will continue to do so. In closing, then, let me summarize the key Space Station Program tasks that I believe we have before us over the next couple of years. We are establishing a permanent facility in space in large part for scientific, technological and commercial purposes, and it is imperative that we continue to understand and anticipate the user needs of the manned base and platforms in the decade of the 1990's and beyond. The technology evaluation and advancement effort is also a key task because this is essential to guide the subsystem design choices that will provide economical, long life, reliable and maintainable hardware for a permanent facility. A thorough and complete preliminary design of the Space Station--both the manned base and the platforms--during Phase B is absolutely necessary to provide the confidence that we can produce the needed elements within cost and schedule targets. The in-house SE&I task is formidable. I have great confidence that the experienced NASA team we have in place, using the latest technology available for communication and data exchange, will accomplish it. The enthusiasm and cooperative spirit of the NASA, industry, scientific community and international partners will provide the impetus we need to meet these challenges and accomplish the definition and development of the Space Station.

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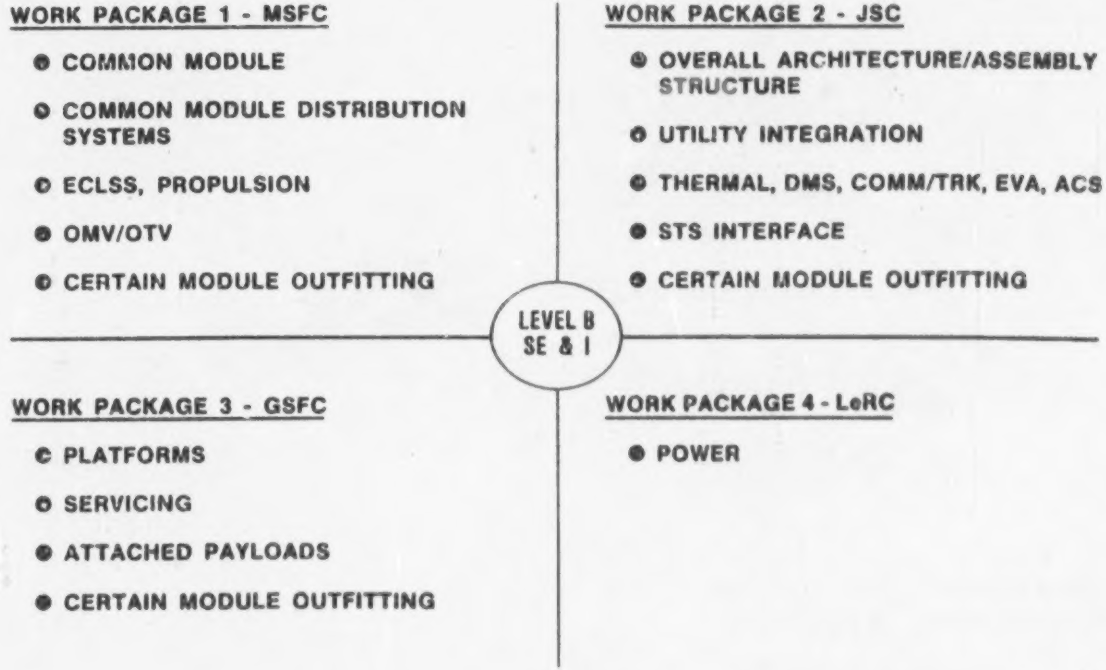
S-84-04281A

Work Package Structure



WORK PACKAGE 1 - MSFC

- COMMON MODULE
- COMMON MODULE DISTRIBUTION SYSTEMS
- ECLSS, PROPULSION
- OMV/OTV
- CERTAIN MODULE OUTFITTING

WORK PACKAGE 2 - JSC

- OVERALL ARCHITECTURE/ASSEMBLY STRUCTURE
- UTILITY INTEGRATION
- THERMAL, DMS, COMM/TRK, EVA, ACS
- STS INTERFACE
- CERTAIN MODULE OUTFITTING

WORK PACKAGE 3 - GSFC

- PLATFORMS
- SERVICING
- ATTACHED PAYLOADS
- CERTAIN MODULE OUTFITTING

WORK PACKAGE 4 - LeRC

- POWER

FIGURE 1

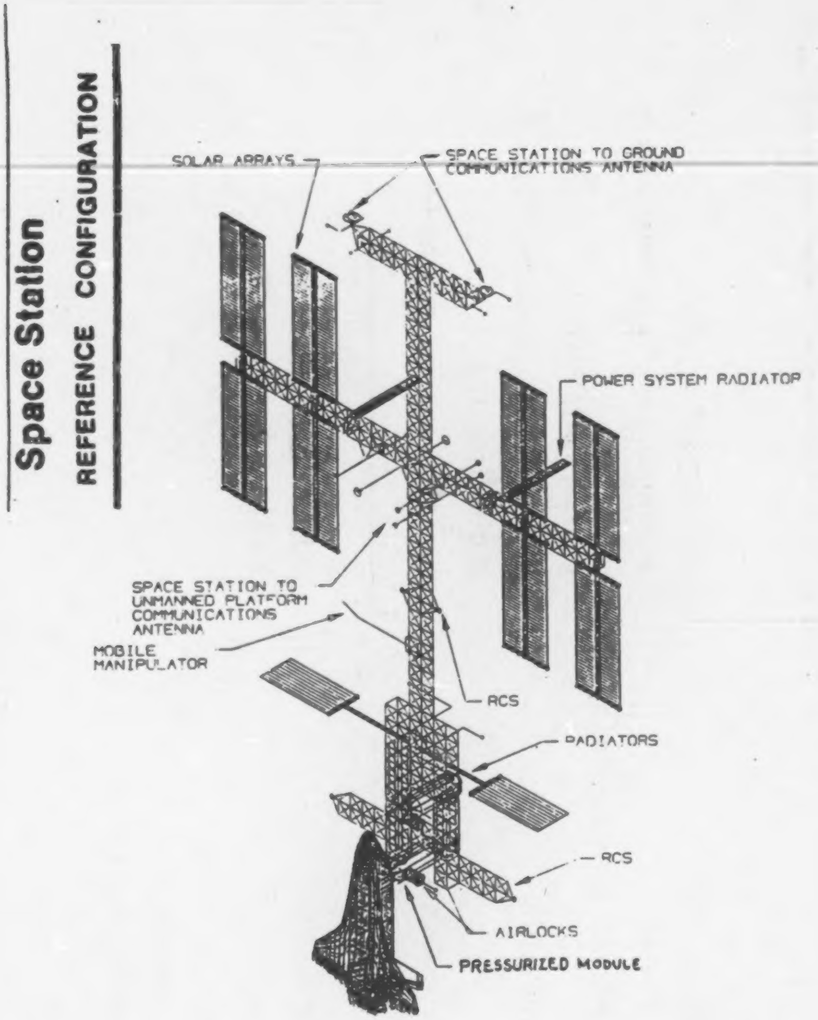

Space Station
REFERENCE CONFIGURATION
SOLAR ARRAYS
SPACE STATION TO GROUND COMMUNICATIONS ANTENNA
POWER SYSTEM RADIATOR
SPACE STATION TO UNMANNED PLATFORM COMMUNICATIONS ANTENNA
MOBILE MANIPULATOR
RCS
RADIATORS
RCS
AIRLOCKS
PRESSURIZED MODULE

FIGURE 2

Space Station PLATFORMS
REFERENCE CONFIGURATION

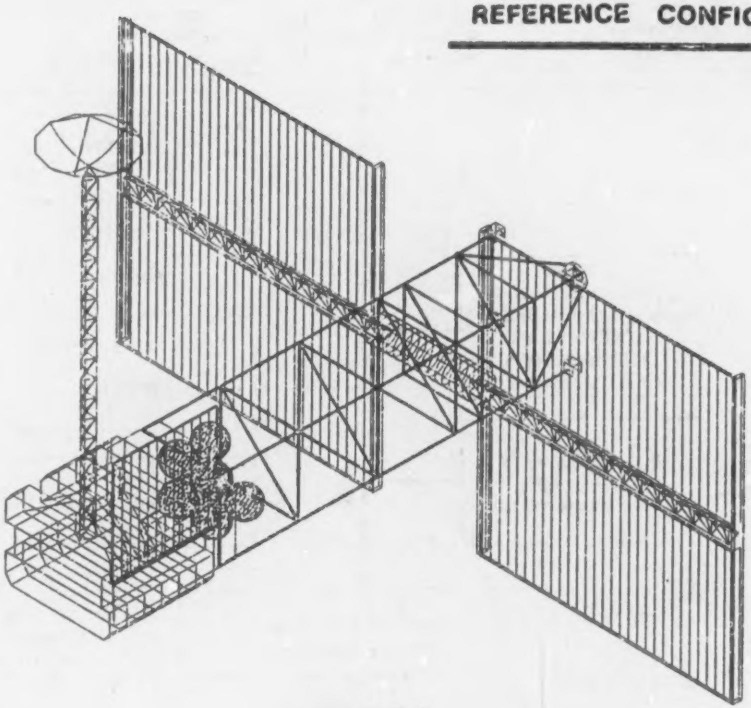
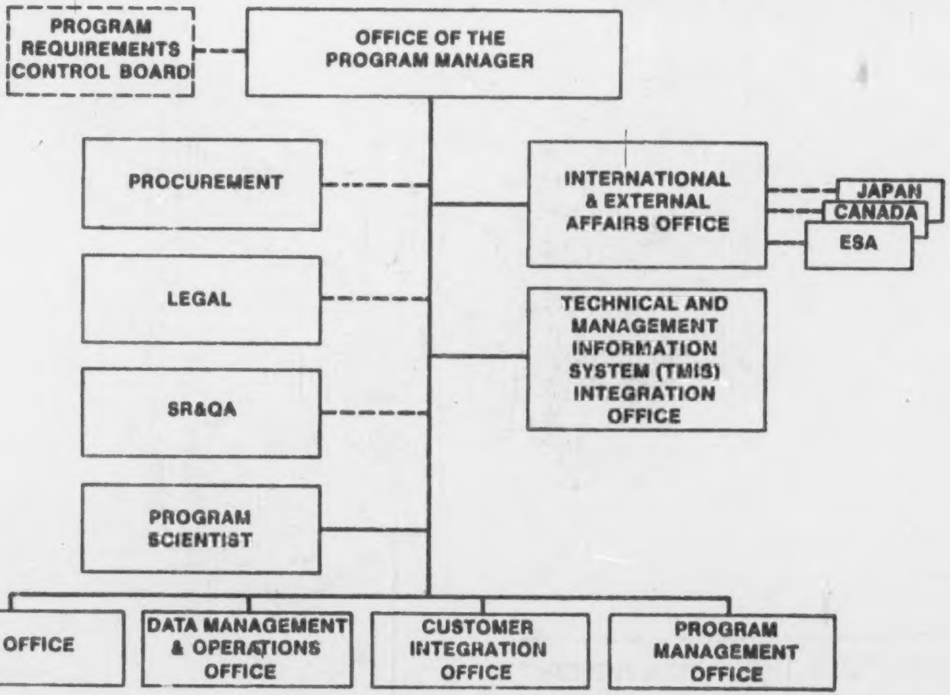


FIGURE 3

NASA
S-85-00158

Space Station
Level B Organization



PROGRAM REQUIREMENTS CONTROL BOARD

OFFICE OF THE PROGRAM MANAGER

PROCUREMENT

LEGAL

SR&QA

PROGRAM SCIENTIST

INTERNATIONAL & EXTERNAL AFFAIRS OFFICE

JAPAN

CANADA

ESA

TECHNICAL AND MANAGEMENT INFORMATION SYSTEM (TMIS) INTEGRATION OFFICE

SE&I OFFICE

DATA MANAGEMENT & OPERATIONS OFFICE

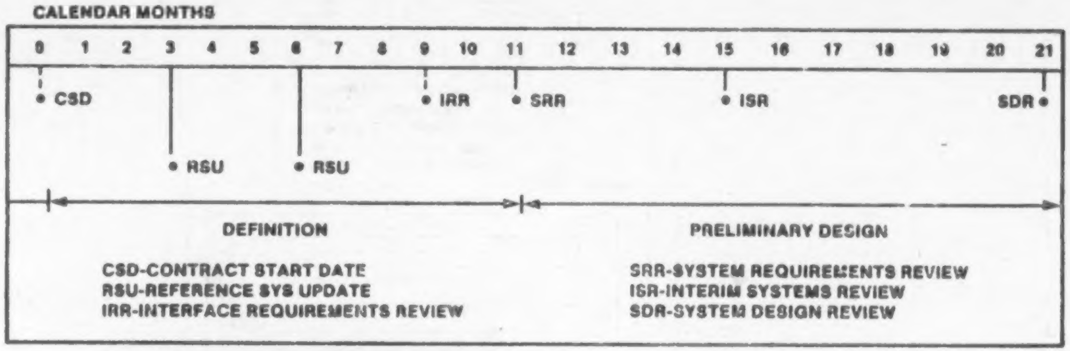
CUSTOMER INTEGRATION OFFICE

PROGRAM MANAGEMENT OFFICE

FIGURE 4

S-85-00156

Phase B Schedule



- TARGET CONTRACT START DATE APRIL 1, 1985
  - START FROM SYSTEM REQUIREMENTS & REFERENCE CONFIGURATION
  - PROCEED TO BASELINE BY MID-TERM
  - PRELIMINARY DESIGN OF BASELINE DURING LAST 9 MONTHS
- SEQUENCED TO PRODUCE PRELIMINARY DESIGN EFFORT

FIGURE 5

S-85-00159

Level B/Level C SE&I Task Flow

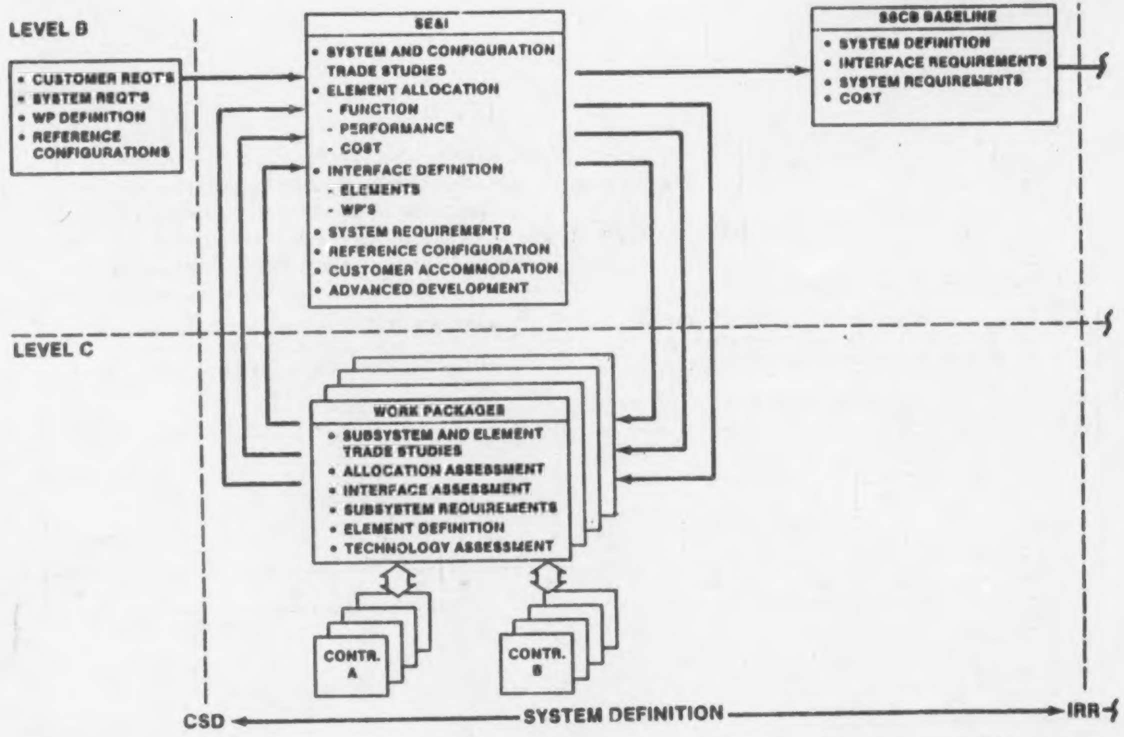
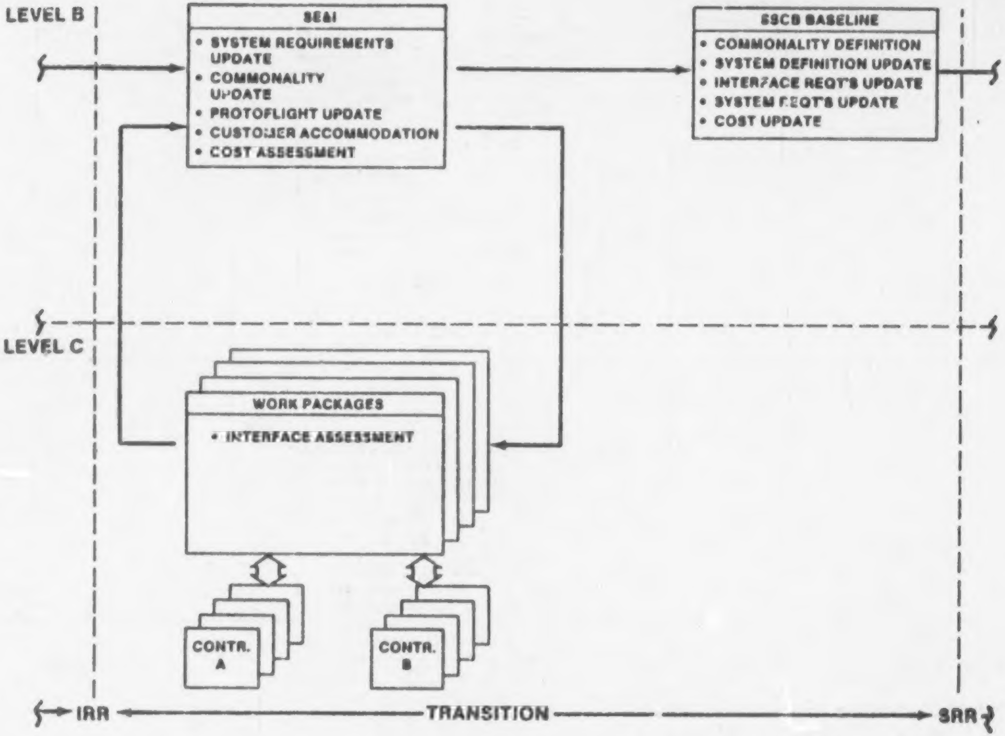

LEVEL B
• CUSTOMER REQT'S
• SYSTEM REQT'S
• WP DEFINITION
• REFERENCE CONFIGURATIONS
SE&I
• SYSTEM AND CONFIGURATION TRADE STUDIES
• ELEMENT ALLOCATION
- FUNCTION
- PERFORMANCE
- COST
• INTERFACE DEFINITION
- ELEMENTS
- WP'S
• SYSTEM REQUIREMENTS
• REFERENCE CONFIGURATION
• CUSTOMER ACCOMMODATION
• ADVANCED DEVELOPMENT
SSCB BASELINE
• SYSTEM DEFINITION
• INTERFACE REQUIREMENTS
• SYSTEM REQUIREMENTS
• COST
LEVEL C
WORK PACKAGES
• SUBSYSTEM AND ELEMENT TRADE STUDIES
• ALLOCATION ASSESSMENT
• INTERFACE ASSESSMENT
• SUBSYSTEM REQUIREMENTS
• ELEMENT DEFINITION
• TECHNOLOGY ASSESSMENT
CONTR. A
CONTR. B
CSD
SYSTEM DEFINITION
IRR

FIGURE 6-1

S-85-00160

Level B/Level C
SE&I Task Flow (Cont)



LEVEL B

LEVEL C

SE&I

- SYSTEM REQUIREMENTS UPDATE
- COMMONALITY UPDATE
- PROTOFLIGHT UPDATE
- CUSTOMER ACCOMMODATION
- COST ASSESSMENT

SSCB BASELINE

- COMMONALITY DEFINITION
- SYSTEM DEFINITION UPDATE
- INTERFACE REQT'S UPDATE
- SYSTEM REQT'S UPDATE
- COST UPDATE

WORK PACKAGES

- INTERFACE ASSESSMENT

CONTR. A

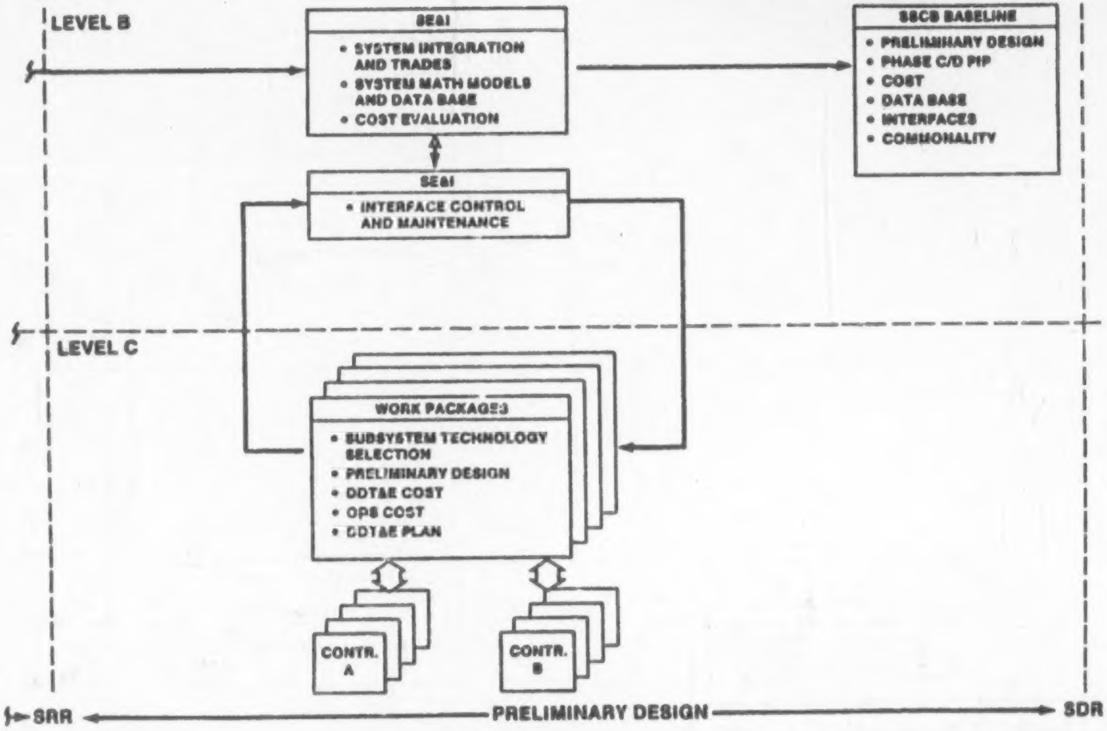
CONTR. B

IRR ← TRANSITION → SRR

FIGURE 6-2

NASA
S-85-00161

Level B/Level C
SE&I Task Flow (Cont)



LEVEL B

SE&I
- SYSTEM INTEGRATION AND TRADES
- SYSTEM MATH MODELS AND DATA BASE
- COST EVALUATION

SSCB BASELINE
- PRELIMINARY DESIGN
- PHASE C/D PIP
- COST
- DATA BASE
- INTERFACES
- COMMONALITY

SE&I
- INTERFACE CONTROL AND MAINTENANCE

LEVEL C

WORK PACKAGES
- SUBSYSTEM TECHNOLOGY SELECTION
- PRELIMINARY DESIGN
- DDT&E COST
- OPS COST
- DDT&E PLAN

CONTR. A

CONTR. B

SRR ← PRELIMINARY DESIGN → SDR

FIGURE 6-3

Mr. Nelson. All right. We would like to question the panel, so I will call on Mr. Walker.

Mr. Walker. Thank you, Mr. Chairman.

The $8 billion of cost that is projected at the moment, is that in your view a fairly accurate projection, and does that include all the launch costs that would be associated with the construction?

Mr. Culbertson. I think it is as accurate as we were able to put it together last year, recognizing that we had not yet begun that effort which we hope will result in understanding what those costs are.

I believe that the configuration that we have sketched and described, Neil has described, and we put in the RFP, is going to require some stretching to get there within the $8 billion. That is the way it should be at this point.

We are going to ask the contractors to stretch with us, but I can't answer your question with any precision for about 1½ years, and that is frustrating, but it is one of the facts of life.

It does not cover shuttle costs. It covers the period of activity during this buildup sequence, but none of the shuttle transportation costs, which is a separate line item within our budget.

Mr. Walker. The man-tended studies that Congress directed last year, how will those differ from what you are proceeding with in terms of the permanently manned station?

Mr. Culbertson. As it was designed in the bill that came to us, it was a delay, fundamentally, in the provisions for habitation. The creation of a system which, during the period that it was man tended before it was fully man tended, habitation would be confined to the space station, I mean the space shuttle, as far as eating and sleeping provisions, and that sort of thing.

Laboratories would be included in that original configuration, but it would be just a delay in the provision for having the crew stay on board in the absence of the shuttle. Neil?

Mr. Hutchinson. I am not sure, if your question was directed on how we are going to do it, what we are basically looking at. We have asked all four of our contractors to examine the man-tended configuration and of course, we would like to make it a minimum scar to the fully manned configuration since, obviously, if that kind of configuration is ever employed, we would intend to grow into the fully man tended configuration. So, we have folded the man-tended evaluation into the fully manned evaluations in a parallel complementary effort.

And hopefully, we will also develop the process to get from a man-tended station physically, to get from that version into the fullymanned, so it is an integral part of the phase B activities and will be up until the midpoint in the study, we hope, to fully characterize the man-tended and how it would fit in the overall definition of the station.

Mr. Walker. It will not necessarily be presented as a separate option that would have a separate budget connected with it?

Mr. Culbertson. That is correct, it would not have a separate budget. It will be an alternate way of getting to the fully permanentlymanned capacity, and that alternate being just a period of delay prior to the time.

Mr. WALKER. So we can envision that it will ultimately then be a means by which opponents going to be permanently manned will suggest a stretch-out?

Mr. CULBERTSON. Well, you said that. I didn't.

Mr. WALKER. It is logical to assume that that kind of a provision within your phase B projections will be used by some probably as a means for stretch-out of deployment?

Mr. CULBERTSON. It would be one mechanism by which people would characterize an argument for stretching the program out.

Mr. WALKER. Your statement, Mr. Culbertson, indicated that program plan will be based upon a detailed definition, because that is the only way we can assure credible costs, schedule and technical projections, and I also heard Mr. Hutchinson talking about how you are going about establishing those details in terms of customers and so on.

One thing that bothers me in all of that is how in the world do they know at this point? Even if you are doing outreach to these folks, how in the world do they have any idea what they will be able to do, what it is they might want to do, and if we define it very carefully in terms of all the things we want to do on this station, and it becomes a station that becomes all things for everybody who can now think of something, don't we in fact maybe lose capabilities that would allow it to be expanded into meeting real needs that are identified soon after the station is in place?

Mr. CULBERTSON. Let me approach that in two steps. You are right, it is very difficult for us to define what people will be doing in space in the latter part of the 1990's or the year 2000. However, for those users who would be using the space station in 1992 or 1993, they must have their ideas pretty well in place now, because of the lead time in developing other kinds of things, instruments which would use the space station.

The definition of its use in its very early period can be done with a reasonable degree of precision. The crystal ball gets foggier as you look out beyond that, and that is why we have designed a program which will allow us to build it, so that in its first use, it can be quite consistent with the relatively well-established user needs, and to then design it in a way that will allow for its growth with minimum impact on budgets and minimum impact on the basic design itself, to design it in a way that it can, in fact, evolve as those user needs become more clearly defined. I think that we will, 4 years from now, have a much better understanding of what it would be used for in 1995 or 1996, and we will start working in the direction of that evolution.

The important thing is in the early part of the design, we design it so that growth can take place easily, and that is one of the things that is characteristic of this configuration. Neil said this will allow us to advance along the direction without great changes in its dynamic characteristic.

Mr. WALKER. In reading the OTA study, or the OTA look at the whole space station concept, I got the impression what they were really saying is that the project looks like a project searching formation, and so, therefore, what NASA is going to have to do is scramble around and try to find a mission for this, so the more things they can build into it, the more it will look like it is real, and has a mission to it.

The tendency will be to answer that kind of criticism with doing exactly that. My guess is we could do something far less expensively and with far more precision, if we target to do a couple of things very well, in other words, build a very good habitat, and service center, and then say to commercial customers, science and so on, that we have a station that if you fly a module in close proximity to it, we can provide you with certain things.

It seems to me that in terms of policy that it might not be a good idea to become all things to everybody, and yet, I see some danger in that kind of attitude developing.

Mr. CULBERTSON. If I can just add two additional attributes to the ones that you mentioned, that is, build a good habitat, and build it so it can handle a reasonable number of people and build that service capability because we have exercised the space shuttle in a service capability and we see the possibilities. If I can add a laboratory to do microgravity processing and to do biological research, or processing, much as we will be doing, as we will begin to get an understanding of in the spacelab. Then, I think you have defined the space station that we intend to build.

Mr. WALKER. I thank the chairman.

Mr. NELSON. Mr. Brown.

Mr. BROWN. Mr. Culbertson, you dealt with the subject of international cooperation here. Could you explain how this affects the cost targets? I understand that we are shooting for something like 25 percent of the cost of the station, and does the $8 billion figure that we are talking about include this, or would this be in addition to the $8 billion?

What is the general picture on that?

Mr. CULBERTSON. We have identified a configuration which is independent of any—this is what we defined a year ago, and it is the U.S. portion of the space station.

In the European Space Agency, they have indicated that they are preparing to study a laboratory and a free-flying platform and the service and the power system and the other utilities connected with that platform and a certain number of ground systems to support those elements, and that they believe that that total activity will be about $2 billion, not the definition, obviously, but the entire development.

In Japan, they had expressed a considerable interest in a laboratory, and in a servicing capability connected with that laboratory, and with certain experiment resources packaged in another module which is connected to a laboratory. They have also indicated some interest in a free-flying platform.

In Canada, they have interest in expanding beyond the remote manipulator that they provided for a shuttle into a space station manipulator and into some other servicing facilities.

We are considering that those things are in addition to the basic space station and during our definition studies, we will be working with all three of their studies to integrate that into a total.

Now, what the final provisions that we put into the system a year from now when we will essentially begin the more detailed design, is yet to be seen exactly how those all flow together, but we have considered that they are in addition to the $8 billion space station.

Mr. **Brown**. I notice that the European Space Agency, particularly the British, seem to have some reservations about moving beyond phase B until certain problems are cleared up with regard to the sharing of technology and some other things of that sort.

I think I would be interested, and probably the whole committee would be interested in the nature of those reservations, and how they will impact the proceeding on to phase C and D, and I would like to anticipate some of the problems that might occur so that we could react in some appropriate fashion to these things.

Would you care to comment?

Mr. **Culbertson**. We did not ask for a commitment beyond their definition studies, because we felt it unrealistic for them to commit to a program before they understood what it was going to cost them, and before we had completed overall configuration study. So, in our trip abroad last spring, we asked for a commitment to do the phase B studies. And, in the same timeframe that our studies will be going on so that the particular agreement that we are negotiating with them today is to establish the operations between this country and ESA and Japan and Canada during these phase B studies.

The European press commented recently on the fact they were not satisfied with the agreement we had reached on technology transfer. Our indications are that the probability is within a week or so, we will be able to report to you that we are in pretty good agreement.

We are going to handle technology transfer in this program pretty much consistent with the export laws that are established, and the agreements that have been reached on technology across the Government lines. And, I think that they fully understand what that means. And, it is just a matter of seeking the right language to show we are going to design interface systems so they will require minimum transfers, and that is consistent with this Federal Government.

I believe we have no real problem.

Mr. **Brown**. Is that the end of my time?

Mr. **Nelson**. Do you have other questions?

Mr. **Brown**. Next round.

Mr. **Nelson**. Mr. Slaughter.

Mr. **Slaughter**. No questions.

Mr. **Nelson**. Mr. Torricelli.

Mr. **Torricelli**. Thank you, Mr. Chairman.

I wonder, Mr. Culbertson, if you could inform us of any current arrangements with the military in this country for access or use of the facility?

Mr. **Culbertson**. The military has not indicated to us that they have any requirements for the space station at all. They have not asked us to provide anything in it.

Mr. **Torricelli**. Has there been communication?

Mr. **Culbertson**. There is active communication with them. I have an Air Force officer, resident in my office, who has become as fully familiar with what is going on. Neil has or will have two officers——

Mr. HUTCHINSON. I have.

Mr. TORRICELLI. Have any assurances been made to the Europeans, Japanese or Canadians that preclude military involvement if it came of interest in the future?

Mr. CULBERTSON. No, we have indicated there is no express need for the Department of Defense today but that we would expect it reasonable to believe that during the course of the operations of the space station there will be some research that the military wants to conduct and we will allow them to do that.

Mr. TORRICELLI. For my own understanding, the achievement of the structure as described to us today is completely not dependent on the participation of any other nation. So anyone who would decide not to participate would not become an obstacle to everything described here today. That is my understanding, is that correct?

Mr. CULBERTSON. We are trying to build it in that direction, yes.

Mr. TORRICELLI. So it would only be enhancement to the extent others want to participate?

Mr. CULBERTSON. Yes.

Mr. TORRICELLI. Let me——

Mr. CULBERTSON. If I could qualify that in one respect.

Mr. TORRICELLI. Sure.

Mr. CULBERTSON. I said the Canadians were interested in the possibility of their technology that they developed using—developing the remote manipulator for the shuttle. We have not foreclosed that as a possibility. But we will study a remote manipulator during our phase B studies and make that decision later on. The final answer is as I have stated it.

Mr. TORRICELLI. Moving to the next question here, by and large is this the application of current technology that we have on the shelf that is readily available, is there much that has to be developed for this construction that is still theoretical or in concept?

Mr. CULBERTSON. Why don't you talk to that, Neil?

Mr. HUTCHINSON. Theory and concept, no, but certainly this station that you see here is, will require considerable advances in technology. I think the key to the technology issue is there isn't any question in any of our minds, we could go build a space station right now with what we have, what you have described as on-the-shelf technology and we could build a pretty good one. And, it would probably last for 4 or 5 years and do the kinds of things that skylab did.

Mr. TORRICELLI. But in this station we are talking about components and materials that do not necessarily now exist?

Mr. HUTCHINSON. No, that is not true. We are talking about advances in particular areas and in particular subsystems where we have proof of concept mostly but need to drive them on that last mile or that last little bit to be certain we understand them. We do have some materials circumstances, for example, we are going to be up there 10, 15, 20, 25 years so we are going to have to do some pretty good studies on materials degradation, atomics oxygen, those things to make certain we don't have a problem.

We don't think there is any technological barrier to make this thing an operative contributing factor to the program for an extended period of time. Most, if you look at the technology areas we are pushing, most of them surround the area of trying to reduce our recurring costs, for example we are pushing the CCLS closure, we are doing that simply because we don't want to have to spend half of every shuttle payload carrying up water and oxygen.

We are pushing the electrical power business because we really want to be able to grow this station from the configuration you see here to a configuration that is much, much bigger, possibly four or five times that much electrical power. We think we will need that much before we are through. If we were to continue to use solar cell technology that would present a frontal area many, many, many acres in size, which again costs us in control propellants and so on.

Mr. TORRICELLI. Let me ask you, how do you see this impacting the shuttle's schedule and its possibility to service commerce and its clientele and gain the revenues that have been projected both in building the station, are we talking about shutting down the current availability for contracts; and afterwards, to service it, does it have any impact on the current anticipated schedule for contract flights?

Mr. CULBERTSON. It will certainly affect the details of the shuttle manifest. During the period we are building it up, we will have a strong demand or requirement for shuttle flights. We think of this being assembled over a period of 9 months to a year and if there are seven flights to do that it will take that much.

Mr. TORRICELLI. Are we out of business for a year in placing satellites in space?

Mr. CULBERTSON. No, we are not. We are building up a considerably larger capability than the seven or nine in a year. But, I think we will find that with the space station we will make much more effective and economical use of the shuttle.

Mr. TORRICELLI. I am not arguing that, I just wonder in terms of what we are doing with commercialization and making this available for American companies, if the current contracts schedule looks like 10 to 12 satellites a year that we are going to be able to contract to place in orbit, can we maintain that schedule during the year of construction of the station?

Mr. CULBERTSON. We have not gotten to that kind of detail but I think it would have a small impact on our use for commercial satellites.

Mr. TORRICELLI. Thank you, Mr. Chairman.

Mr. NELSON. Thank you.

Mrs. Meyers.

Mrs. MEYERS of Kansas. The projected costs you have talked about as being $8 billion that is the U.S. share, that is over how many years?

Mr. CULBERTSON. Well, it goes through 1993, so that—is that 8 years?

Mr. SHEAHAN. Yes.

Mrs. MEYERS of Kansas. You commented that Europe was talking about sharing costs to the level of about $2 billion.

Mr. CULBERTSON. Not sharing, you know, they expect to spend $2 billion as a portion of their participation in the program.

Mrs. MEYERS of Kansas. Yes.

And just in general cooperation with us?

Mr. **Culbertson**. Yes.

Mrs. **Meyers** of Kansas. And you also mentioned Japan but I don't recall that you mentioned an amount that they would contribute.

Mr. **Culbertson**. They are estimating that it's about a billion dollars and that Canada is somewhere around $300 million. These are the numbers we are using currently.

Mrs. **Meyers** of Kansas. And what about contributions of private industry? Do we have any way to estimate what those are going to be?

Mr. **Culbertson**. Well, the only reason—the principal interest we see in the private industry is with free flyers which would fly perhaps co-orbitally in the same orbit as the space station in which we could move to the space station for servicing.

There is interest, for instance, on a free flyer which allows materials processing functions—which would support a materials processing factory in space. And, there is private interest in developing that system. There are also private interests interested in developing smaller free flying spacecraft. We have encouraged the private sector to approach us on possibilities for participation in the primary vehicle, manned or unmanned platforms, but the major interest is just in platforms.

We will continue to be openminded, however, and encourage people to be creative and come to us with ideas about their ability to participate in the program with private sector money. The limitation is that the private sector wants to make money on it, obviously, and it's a little more difficult than smaller projects such as launch vehicles and that sort of thing where it's not too difficult to visualize their development being offset by renting or selling or providing services.

That has not come—it isn't moving very rapidly today despite the fact we are trying to encourage people to come to us. But we will continue to do that.

Mrs. **Meyers** of Kansas. And of this total, what amount is being requested in the fiscal year 1986 budget?

Mr. **Culbertson**. $230 million.

Mrs. **Meyers** of Kansas. Thank you, Mr. Chairman.

Mr. **Nelson**. Mr. Mineta.

Mr. **Mineta**. Thank you, Mr. Chairman.

I apologize for not having been here when you made your very fine presentation, and the showing of the film, Mr. Culbertson.

I wonder, first of all, what capabilities do the Russians have in this area of their work on the space station?

Mr. **Culbertson**. Their present Salyut is—sometimes it has two occupants, sometimes three. They have been flying it for about 8 years. There have been 8 or 10 individual missions to it and they have gone up to 250 days, approximately, 234 programs.

These are missions that long with the same crew. They send crews up and visit once in awhile.

Now, it's an aggressive program. They keep it manned most but not all of the time. They have that space station that the Salyut has been upgraded several times and gone through an evolutionary process of its own, increasing power and capability.

It's relatively small. The primary vehicle if you took the power system off and the reentry vehicle, it could sit inside the cargo bay of the shuttle which gives you an indication of scale. The current estimate which has been published is that there is reason to believe that they will go up to six or eight people within the next few years but that they are aiming toward a significant space station in the early to mid-1990's, and I have heard estimates up to 100 people. I find it rather difficult to absorb that number but a sizable capability is involved.

They are also developing a launch vehicle, an unmanned launch vehicle—well, we don't know whether it's manned or unmanned, I guess, capable of lifting about 300,000 pounds which is about the same class as the Saturn V; and they have been flight testing small versions of manned reentry vehicles. So, that they clearly have a plan for an aggressive manned program in the future.

Mr. MINETA. And what you are proposing here is—has more capability than what they are—what they are talking about doing, or what we know of what they are doing?

Mr. CULBERTSON. This has considerably more capability than their present capability. It's not—it does not have the capability of broader estimates I have seen coming from the Department of Defense about their future interests. This is less than some indications on their future interests.

Mr. MINETA. Is this space station a necessary precursor to anything we may be contemplating doing, such as the lunar or planetary explorations or any other kind of long-term initiatives that we might have?

Mr. CULBERTSON. Well, that depends somewhat on the analysis, but a major portion of our future thinking about this space station is that it will supply, serve as a place where we can assemble larger space systems and launch them from the low Earth orbit of the space station.

To the degree that that is possible and stay within the general capabilities to get to our space station provided by the shuttle, to the degree this is possible and it's of course possible, then we can launch out of low Earth orbit considerably larger things if we have a space station.

Therefore, if we ever return to the Moon or if we send larger things to geosynchronous orbit or planets, the possibilities provided by a space station will significantly enhance national capabilities to place large payloads into those trajectories and orbits.

That is one part of the answer to your question.

Second, this is going to enable us to understand man's function in space, our own understanding of how to protect a man, to make him productive during long periods of weightlessness in a spacecraft like this; and, if we move outside of low Earth orbit with manned systems, I think it's very clear that we will have to go through this kind of capability to get the knowledge and the understanding to permit us to go to those more capable systems, larger systems in the future with any confidence at all.

Mr. MINETA. As I understand it, NASA is going to have this available for commercial users, is that correct?

Mr. CULBERTSON. We will have it available for commercial users and we will have it available to provide service to free-flying satellites that commercial users may either develop themselves or be used or provided by someone else.

Mr. **Mineta**. If I might very quickly, Mr. Chairman, in the past NASA has spoken of an $8 billion ceiling on station costs—excuse me—and Mr. Beggs spoke of "buying the station by the yard" quote unquote, implying if costs increase less capability would be procured.

It now seems that the $8 billion has become a floor on costs and I am wondering if that is correct?

Mr. **Culbertson**. Well, NASA isn't very enthusiastic about ceilings, let me point that out. I don't consider the $8 billion as a ceiling or a floor. No, I think it's up to us in the next year-and-a-half to define a space station or a range of space stations which bracket $8 billion because I think that would be held—$8 billion as a ceiling or a floor is a limitation on which at this point the program should not be forced to live with.

Mr. **Mineta**. If we are talking about commercialization, what is the challenge to the engineers or to the agency to keep those costs down if we don't put emphasis on costs?

Mr. **Culbertson**. The emphasis will be on cost. I didn't mean to deemphasize cost but there are three principal things that we have to work with. We have to work with cost, schedule, and performance.

I believe that it's appropriate during the definition phase to have a certain elasticity in those so that we can come to the Congress with the best station we think appropriate for the Nation. That could be less than $8 billion, or approximately $8 billion but the $8 billion was, you must realize, a very preliminary kind of a number that our best heads put together at the time that we could do it for, when it was—when we told you that a year ago.

That is still the costs we are looking at.

I think the motivation is there because the spirit of NASA is to try to deliver to this country the best possible space station we can get for whatever the cost is that is established between ourselves and the Congress.

I think the motivation is there to be very cost conscious because we want to deliver the maximum capability for whatever it is we spend.

Mr. **Mineta**. Is part of that mission also to help industry get into space?

Mr. **Culbertson**. Very definitely, yes. We have worked very closely with the 18 or so private industry, companies in the private industry, who are investing money today to see how they might move into space. There is that group of them and we have sat down with each one of them in some detail and said, what kind of attributes can we put into the space station which will be useful to you which will enhance your opportunities in your own view? That is a principal part of our thinking today in what the capabilities of the system should be.

Mr. **Mineta**. Thank you very much.

Thank you, Mr. Chairman.

Mr. **Nelson**. I want to thank you for the additional private discussions that we have had both here and last week down in Houston. I think you all are doing a terrific job and I just want to underscore a couple of things here that I would like to get into the record.

Your original request to OMB was $280 million, they gave you $230, that was the final agreed figure.

Mr. **Culbertson**. Yes.

Mr. **Nelson**. Basically that impacts the scheduling that you have to stretch it out another 3 months?

Mr. **Culbertson**. That is correct.

Mr. **Nelson**. So you have a start of January 1, 1987 instead of beginning the fiscal year 1987 which is October 1, is that correct?

Mr. **Culbertson**. Yes, that is correct. You say start, that is the completion of phase B.

Mr. **Nelson**. Let's talk about operating costs. We build and we don't attend to the costs that are required to have us operate it. What attention is being given to the designs that will minimze these costs? And how will that operating cost offload to the users?

Mr. **Culbertson**. Why don't we both take a shot at this. Why don't you go first, Neil.

Mr. **Hutchinson**. I'll let you work on the user part of it.

As far as, Mr. Chairman, the operating costs themselves, I think we have really got kind of a three-pronged attack we are looking at here in the phase B studies and I would say that the recurring costs activity we are examining is paramount in all of the design tradeoffs and in fact if you went down and ticked off most of the things that were concentrated on in advanced development, they are aimed at making operating this thing a cheaper thing to do.

Now, I am not saying it is not going to take a portion of the agency's budget to keep the space station going on but we are trying very, very hard to factor in things like a closed loop ECLSS, things like the solar dynamic power system which will allow us not to have to put so much propellant out there and so on and so forth.

I believe that another part of the thrust, of course, is the fact that we have an operations activity both at the headquarters and in the field that is looking specifically at operating principles with regard to the station. And we are examining things like how quickly can we make this thing autonomous from the ground so we don't have the mission control concepts involved with it that we have with the shuttle.

We are looking at things like trying to make the use of it, optimize the man's principles there where he is not spending all his time working on space station things and not working on things that are more productive, or more important that we may be able to charge somebody for if we had a paying customer on board.

So I think there is a great deal of emphasis on recurring costs in phase B, and operating costs and that we ought to have by the time we finish phase B activity a fairly good handle on both those parameters.

Mr. **Nelson**. Yes.

Mr. **Culbertson**. Neil didn't mention, I don't think, our emphasis on commonality where we can achieve commonality to be cost effective and that has to do with not only initial production costs but in logistics. It is terribly important when we operate this for 25 years that we do the things today that will lower the cost of the logistics system. Two other things that I would mention is that we, I think earlier than any other program that I have been involved in, both of us have put operations organizations into our own organizations. I have an office for operations, Neil has an office for operations and these people are thinking today what can be done both to develop the operational concept and then to see how that operational concept is reflected in the design of the system.

We will in about 2 weeks have a symposium on operations getting together the best heads that we can find who have participated in operations in anything like the space station to sit down and share thoughts on how you operate a machine like the space station. It is clearly something different than NASA has ever operated.

The final thing we have tried to do to hold down operations costs is the thing Neil mentioned earlier where we would do the systems engineering and integration in-house. That means we will not have a prime contractor who must remain with us for the duration of the program. We will retain the corporate memory if I could use that expression in-house and be—have some freedom in the way we select our contractors' support downstream.

I haven't any real answer to the other part of your question, how are we going to reflect these costs in—operational costs in user costs. But I believe that the agency has said pretty clearly that we think it's important to develop user costs which will enhance the opportunity for private sector investment in space; and, I would hope that we have the flexibility to continue to do that kind of thing in the space station when we get to the point of determining what those user costs will be.

Mr. NELSON. I think what you are doing is well and good. Now will that enable you in a year to commit to us what the operational costs are going to be?

Mr. CULBERTSON. I cannot promise you that we will commit to you. We will in a year give you our best possible indication of what the user costs will be because we will know much more about the configuration.

The pressure you would like to apply is matched by the pressure of the ESA because in our invitation to have foreign participants in the program last spring when we made these invitations they included participation in development, participation in use, and participation in operations.

So there is great interest abroad and we will be working as hard as we possibly can. It's a little early to commit because we will just have completed the real establishment of what the configuration will be and it's from that that we will have to try to get to the point where we can commit something.

Mr. NELSON. At that point could you tell us that certain development of the station ought to be delayed until specific technologies could be produced to reduce development and operating costs?

Mr. CULBERTSON. That is the purpose of the pressure on advanced development right now and one of the reasons that it is so important that we keep the kind of advanced development program that we have planned for 1985 and 1986 on track and moving forward.

Yes, I think we will be in a position that we will know whether or not there should be a delay. We are designing this system so that as technology advances it can be upgraded and we can evolve into those technologies. I would hope we will come to you and tell you that we understand what the technology program is well enough to proceed. But we will be prepared to talk to you in that sense.

Mr. HUTCHINSON. I would like to add to that, Mr. Chairman, if I could.

Although we are, certainly will be back here in 1986 with a lot more data and in 1987 with even more, the way the program is structured going into C-D we probably will still be operating on subsystem choices that might affect operating costs like film inch and logistics and trying to drive as much commonality into this as possible. We may not have made all those choices until we get to the C-D phase and I would imagine our preliminary design, I believe, is April of 1988, that is the PDR date, and I would think some of those things still may be floating a little bit.

Each time we come, I am sure we will have a lot better answer on which to base our estimates and so on. But for example, the solar dynamic and photovoltaic I would expect to still be going on when we are here next year.

Mr. CULBERTSON. I asked Dr. Gilruth one time during the Apollo Program, and he was director at Johnson at that time as you recall, I said, "how much did you count on in the way of developing technologies," and he said, "well, for a major program he thought you could go ahead and proceed on the belief that you could make one or two orders of magnitude improvement in certain technologies," and of course, the Apollo Program did.

The shuttle had two areas in which I think there were major advanced required, one was the main engine, one was the way we handled the thermal protection system.

I feel pretty comfortable that in this program we don't have any technologies that require that kind of improvement before we can commit to them. Do you agree with that?

Mr. HUTCHINSON. I agree with that.

Mr. CULBERTSON. There are a lot of important things that we can benefit from but there are no real show-stoppers as far as we can see today.

Mr. NELSON. I think that you all have done a very good job and as we question the expenditure of these funds in the future, I think that the word of what the concept is has got to be spread. The fact that it's going to be a national laboratory. The fact that it's going to be an observatory and servicing facility and transportation mode and launching point to the heavens and so forth and so on, an assembly facility, manufacturing facility, and so on.

That is all a part of building the case of whether or not we go forward with the expenditure of these funds.

I think, also, that the showing that the technologies that will be developed or worthwhile in stretching our knowledge in new technological development, and the application of that here on earth, for example this alternative method of the power package—just off the top of your head, what could that do for us if we can develop that and put that in the place of this, you have explained how it would take up so much less room than the solar arrays.

What might that application have here on Earth?

Mr. CULBERTSON. Well, it really is built on terrestrial application. The kind of—this is not a——

Mr. NELSON. This is solar dynamics now, is that correct?

Mr. CULBERTSON. Yes, solar dynamics consists of two things; one, collection of solar energy and storage of that in the form of heat and the storage of the heat in a way that it can be extracted to run an engine. The thermal cycles this represents are cycles that are well understood on the ground and have Earth applications.

We will be doing things in storage medium, the way to store thermal energy which could very well have applications on the ground using some unusual materials and heat storage techniques. We will have optical coatings on the collector, the dish that collects the energy and reflects it to a specific point. They are coatings where our major problem will be prevention of contamination. I don't think that that technology may or may not have application here on the ground.

I think we will advance the use of the particular thermal cycle engine that we use and the basic technology for that category of engine somewhat particularly in lighter weight materials, longer lasting systems. Perhaps the best thing that we can come out of this with for terrestrial applications will be the development of systems which are extremely reliable. We will maintain this system but it cannot break down every other day and I think that the things that we do to make sure that these systems continue to operate properly for a long period of time are very important.

Now, in that system we will also have some highly automated systems for the control and distribution—or, the control of the power as it comes from the collector and is distributed among the space station.

I think the logics that are developed for the processors of the electrical energy, that sort of thing will probably have lots of applications on Earth. But that is an appropriate, the only appropriate comment I could make on all the automated things we have in the space station.

Mr. NELSON. Take another technology you have to be developed that we don't have, that is the closed life cycle where humidity and waste in the station will be broken down which will resupply oxygen which will resupply pure water—we don't have that capability now, do we?

Mr. CULBERTSON. Not that I know of, but I am not the expert.

Mr. NELSON. Is that not what you are looking to, Mr. Hutchinson?

Mr. HUTCHINSON. Oh, yes, sir.

Mr. NELSON. We don't have to resupply water and oxygen and all of that?

Mr. HUTCHINSON. Yes, sir. We are in a position now, we have gone far enough with that technology where we have completed proof of concept. Of course it's not in widespread terrestrial use at all but the fact of the matter is that some of the techniques that are used in that kind of thing could be used in the terrestrial applications if we chose to do that.

I think you will find even in the ECLSS situation where very, very small parts of that process find their way into strange places like part of that process reclaiming wash water, we are going to use a fairly sophisticated filtration system that doesn't require any electrical power.

You could envision if that is totally successful in reclaiming it to the extent you could drink water you took a shower in; that very possibly that kind of application could find its way into a home and begin to make our water system a little more useful in a sense of the fact that we throw everything away that we use for utility water in a home.

Sooner or later we will have to do those kinds of reuse over and over and over and over again. The entire closing of the ECLSS system since we have basically a closed ecological system on Earth with plants and water and the atmosphere and so on, is probably not as germane as those individual parts.

Mr. CULBERTSON. I think the monitoring of the atmosphere and understanding what particulates are those we can live with for long periods of time, and monitoring for those particulates and learning what to do about them if they would be in the contaminated atmosphere will also be of use terrestrially in a variety of places where the preservation of the pure and perhaps sterile air supply is necessary.

Mr. NELSON. It would be the development of that system that we would have to have, would it not be true, if we were going on a Mars mission?

Mr. CULBERTSON. Absolutely.

Mr. HUTCHINSON. Or go back to the Moon or almost any other enabling thing that is away from a support system, from a transportation standpoint.

Mr. NELSON. Do any of the members of the committee have further questions?

If not, we will close it out with this one then.

Let's put on the record what do you see are the—available information now indicates that the benefits of the space station will exceed the benefits of alternative methods of accomplishing NASA's goals for a space station?

Mr. CULBERTSON. That is an interesting question.

In 1969 and 1970 when we were debating a space transportation system and what was the next step to take beyond Apollo, there was a study done at the request of the White House with participation of the White House which led to the conclusion that the things that we should do have major significance would be to get away from—provide a way to get man and equipment into space relatively conveniently and in a straightforward way and to provide a place in space to which these people would go. We had up until that time, we have up until today, generally speaking in all of our manned systems, we have been a visitor. We have gone to space or to the Moon and we have picked up all of our things that we could and we came back home. That study indicated that those were the two major directions in which the national program should go. So that we could get beyond the point then where we would put us, a satellite into space and leave it there until it died and then abandon it and replace it with something else.

We concluded, this Nation concluded it couldn't develop both those capabilities at the same time and we elected to build the space shuttle as the first leg of this dual capability. It was with completion of, essential completion of the Shuttle Development Program and the successful operation of shuttle over a significant number of flights that we came to the point we felt now is the time to add that extra leg.

I think that there are analogies one could draw but fundamentally we are today limited in what we can do in a lot of different ways. We are limited by what we can send beyond the surface of the Earth. We are limited virtually to the capabilities of the shuttle which is a large limit I understand but it provides an upper threshold that we cannot go beyond until we can develop some capability manned or unmanned to take two shuttle flights worth of capability, perhaps a propulsive stage and payload in two separate flights and put them together and go out of low Earth orbit with that combined capability.

We can, if we can use this as the transportation mode that I referred to, and we will have provisions in this initial configuration to add a propulsive stage at the right time, but we can break through this very realistic limit that we have and the capability to send things beyond low Earth orbit and we can take a number of flights and assemble them. We could with this space station assemble large systems which are totally beyond our capability now except as they can be totally automated and we are doing that very well but there are upper limits to what you can do with the automated things you can take in the shuttle cargo bay, so we can break through weight and size limitations with a system like this.

There are real limits to what can be done today for the kinds of materials processing interests that our industry has. We have had them work with us over the last 2 years in defining how they would use the space station to provide products to be worked in their facilities to remove products and make sure these facilities continue to operate. So, I am convinced as the industry I believe is, that with a space station we can open up new avenues for opportunities for commercial applications, for industries to make a profit in space and after all that is what industry is fundamentally all about.

This will provide the kind of capabilities for looking outward that will allow us to have large instruments, either attached to the space station or flying separately in the forms we have talked about, but with the presence of man available to repair, replace, refurbish, and update, which is the basic problem in the Hubble space telescope, for instance, it will be man-tended. I think any instrument of that size will significantly—can be significantly enhanced if we have the opportunity to maintain it over a period of many years just as our terrestrial telescopes are.

Is there a way we can absolutely quantify the $8 billion? I don't know and I rather doubt there is. It seems to me, however, that it provides a threshold in which there are enough new opportunities. We are doing exciting things in and from space. And it's clear that that benefit will come.

I have talked perhaps too long and maybe one of my colleagues would like to add a thought to it.

Mr. **Walker**. Could I ask a followup to that, we have developed some figures recently which show that for every dollar that has been invested in space thus far, there—for every billion invested so far there has been a $23 billion payoff into the GNP of the country.

Is there any reason to believe that the space station will be any less than that 23 to 1 payoff? Is there any reason to believe it might be more than that?

Mr. CULBERTSON. Oh, I think it will—to the degree that it is a valid number and I am not challenging your number but those numbers are rather subjective; to the degree it's a valid number I am convinced the space station will be more than that, just because of the entirely different class of things that can be accomplished when you have something like the space station.

Mr. NELSON. Why don't you get somebody in NASA to look at that a little more? That would be very interesting.

Mr. CULBERTSON. We'll do that, Mr. Nelson.

[The information follows:]

Several studies have been done attempting to identify and measure that portion of economic growth attributable to technological progress due to the space program. One was done by Midwest Research Institute (MRI). MRI concluded that the $25 billion (1958) spent on civilian space R&D during the 1959-1969 period returned $52 billion through 1970 and will continue to stimulate benefits through 1987 for a total gain of $181 billion.

Chase Econometric Associates conducted another study and determined that society's rate of return on the NASA expenditures was 43 percent, compared to 33 percent estimated by MRI.

These studies utilized various econometric models and various assumptions had to be made. But the important point to derive from these studies is that the dollar invested by NASA is returned many fold to the economy of the United States.

Mr. CULBERTSON. I think it's suspect that the agency asking for the money comes out with an economic analysis that says it's really great. I think you are not asking for that.

Mr. NELSON. I understand. We can find the source.

Mr. CULBERTSON. We can provide some information as to where we developed that ratio if that would be of any help.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. CULBERTSON. I think the relationship of what you have done to the space station is something we would like to produce.

Mr. NELSON. Mr. Brown.

Mr. BROWN. The Department of Agriculture doesn't hesitate to specify the benefits from agricultural research in terms of $30 or $40 per every dollar invested. Maybe that is an exaggeration but at least they compile the figures in order to justify the expenditure of those funds.

I see no particular reason why NASA shouldn't be in the same boat.

Mr. NELSON. There is no reason you can't have self-serving declarations around here.

Thank you, Mr. Brown, for pointing that out about another Federal agency.

Mr. Hodge, you looked like you had something to add to that. What were you about to say?

Mr. HODGE. As far as the cost benefits are concerned, I have heard Mr. Beggs talk about this subject many times and I happen to agree with him absolutely on it and that is that the research and development where the Government steps in where industry cannot afford the risk has always paid off in this country.

It's my personal belief that it's our willingness to do that, and I think NASA is exemplary of that process and it has resulted in our industry growing as fast as they have. Perhaps the single best example of that is the communications satellite business. That was a gleam in somebody's eye in 1945 and it was thought of as science fiction. We put the money into the space research to do that, we set up a mechanism to transfer that to industry, industry took it over, it's now the largest growing commercial business in this country. I think we will see more of that as we begin to do that.

Mr. BROWN. You wouldn't like to point out it was a British subject who made that projection in 1945, would you?

Mr. HODGE. I was refraining from doing that, sir.

Mr. NELSON. Gentlemen, we appreciate your participation, I think it's almost symbolic that you have discussed the space station and talked about the international participation to the tune of about $3.5 billion of international participation while at the same time we had two members of the Japanese Diet here present for the testimony. That we are going to hear a lot about in the future and I thank you for your participation and I want to call up Mr. Robert Aller now, the Office of Space Tracking and Data Systems.

While Mr. Aller is coming up, he has had the flu and he has been patiently waiting through all of this. I want you to know that I offered that you could go first, Mr. Aller, since you were suffering with a medicinal malady.

Mr. CULBERTSON. Thank you, Mr. Chairman, for this opportunity.

Mr. NELSON. Yes, sir.

Of all the people sitting in the front row, I see you look the healthiest.

STATEMENT OF ROBERT O. ALLER, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE TRACKING AND DATA SYSTEMS, NASA, ACCOMPANIED BY NORMAN POZINSKY, DEPUTY, AND RONALD R. DAPICE, DIRECTOR OF ADMINISTRATION AND RESOURCES MANAGEMENT

Mr. ALLER. Mr. Chairman, members of the subcommittee, thank you for recognizing my problem. I will attempt to get through the testimony without losing my voice.

We appreciate the opportunity to present our budget request for the Tracking and Data Systems Program.

With your permission I will submit the written statement for the record and summarize the major elements of the program in our request.

Seated with me at the table are Mr. Norm Pozinsky on my right, my Deputy, and Mr. Ron Dapice, Director of Administration and Resources Management.

As mentioned last year, we are in this transition from a ground tracking network to space tracking capability for low Earth orbit missions. This transition began with the launch of the first tracking and data relay satellite in April 1983 and will be completed with the launch and checkout of the third tracking and data relay satellite later this year. The major upgrade underway that we spoke of last year in the deep space network to meet the requirements to support distant planetary missions will be completed this fall on schedule.

NASA's communications systems are also transitioning to provide current technology with the time division multiple access [TDMA] system.

Since the details of each program are included in my statement for the record, I will briefly summarize only the major aspects of our program and the 1986 budget requirements.

As shown in figure 1, if I may have the first Vu-Graph—we are requesting a total of $824.5 million for 1986 to continue to provide tracking, command, data acquisition, and data processing support to ongoing NASA flight projects and for preparations to support upcoming missions. The increase from the current 1985 budget to the 1986 request is principally due to a prepayment on the outstanding Federal Financing Bank [FFB] loans extended to finance the TDRSS Program. This prepayment will reduce the total interest cost on the TDRSS loans and thereby reduce the total program cost. Excluding the prepayment and allowances for inflation, the 1986 dollar level would be approximately $40 million below the 1985 budget.

I would like to point out that this budget does assume the successful launch and checkout of TDRS-2 scheduled for March and TDRS-3 scheduled for later this year.

I will now turn to the various elements of our program. The first is the space network. In 1986, we are requesting $400.8 million for the Space Network Program of which $257 million is provided for the annual payment to the Federal Financing Bank [FFB]. That is $47 million more in 1986 going to the bank. The remainder of the requested funding will provide for the completion of the TDRSS on-orbit network; and for the engineering and operation of the systems.

During this past year, as shown in figure 2, significant progress was made toward the operational space network. TDRS-1 successfully supported five shuttle missions in 1984 and extensive testing was completed. This testing revealed that the spacecraft operated as designed, with the exception of the KU-band failures which I reported to you last year; however, numerous operational problems were encountered at the White Sands Ground Terminal as one might expect in initiating a new operational concept.

These problems have been or are in the process of being corrected. A recent photograph of the White Sands Ground Terminal is depicted in figure 3. In addition to the system testing, we have also modified spacecraft 2 through 6 to correct the problems which caused the KU-band failures on spacecraft 1.

This year, we plan to complete the three satellite configuration which will be accomplished with the launch of TDRS-2 scheduled for early March on STS 51-E and followed by the launch of TDRS-3 later this year. Figure 4 shows TDRS-2 in preparation for launch at the Kennedy Space Center. That is an interesting shuttle load by the way. It shows, of course, the TDRSS on the IUS launch vehicle, upper stage, and above that the Teleset satellite in its cocoon. That is the largest payload yet carried by the shuttle. Our weight is about 45,000 pounds with the IUS, Telesat is about another 8000 pounds.

Representing the first period of full TDRSS operational system will be 1986. TDRSS will be supporting the space shuttle missions and will continue to provide support to Landsat, and other operational missions including the space telescope.

For the ground networks, we are requesting a total of $219.3 million to meet the ground networks support requirements. In 1986, we will look forward to continuing the support of NASA flight projects, both in the near-Earth region and in deep space. The ground networks will consist of the Spaceflight Tracking and Data Network [STDN], the Deep Space Network [DSN], and the ground tracking and data acquisition support for the aeronautics, balloons, and sounding rocket programs.

In anticipation of the TDRS era, we are continuing to make substantial reductions in our ground tracking network that support near-Earth orbit spacecraft. The operation of the Spaceflight Tracking and Data Network has been reduced by about one-half over the past 5 years. That is in manpower, link support and overall facilities. And most of the other stations will be closed or transferred to other agencies when TDRSS becomes fully operational.

We will have completed our Network Consolidation Program at the Goldstone, CA; Madrid, Spain; and Canberra, Australia sites as scheduled by the end of this month. This program consolidated all facilities at the Deep Space Network stations under the single management of the Jet Propulsion Laboratory. Figure 5 shows the station reconfigured under this program at Canberra, Australia. This Vu-Graph indicates a 26-meter antenna in the foreground, the large 64-meter behind that, a 34-meter to the right and a new 34-meter in the far background. The antenna in the front is the consolidated antenna from the STDN network into the DSN network. We have done that at all three of our sites and that was scheduled about 3 years ago and we will complete on schedule this month.

Figure 6 depicts our mission support plans for the ground networks—1986 is an extremely busy year in the Deep Space Network with major mission support periods throughout the year.

Support for the International Cometary Explorer [ICE], mission will continue after its encounter with the Giacobini-Zinner comet in September 1985. The network, augmented by non-NASA facilities, will support the Voyager 2 spacecraft encounter with the planet Uranus in January 1986. Tracking the USSR's two Vega spacecraft for the European Space Agency will occur prior to the March 1986 encounter, as they approach the comet Halley. The data obtained will permit the European Space Agency to improve targeting for their Halley's probe—the Giotto spacecraft.

The DSN will also provide backup tracking for Giotto under a reimbursable agreement with the European Space Agency. In May, the launches of the Galileo and Ulysses spacecraft will be supported as they start their journeys to Jupiter. This support, discussed above, will be in addition to the continuing support of man's only spacecraft exploring the outer solar system—the two Voyagers and Pioneers 10 and 11—as they seek the outer limits of the solar system. The DSN upgrade is proceeding very well and will be completed by 1986. As you may recall, this upgrade will give us a modern, efficient ground network with new capabilities to combine signals from several antennas to obtain more scientific data. The most pressing need for this capability is to receive more images from Voyager as it encounters the planets Uranus in January 1986. Construction is now complete on the new 34-meter antennas in California and Australia to increase the capability of the DSN to support these encounters as well as other DSN missions.

For the Communications and Data Systems Program in 1986, we are requesting a total of $188.2 million. This program forms the vital link between the data acquisition stations and the users. As I mentioned earlier, our communications system will incorporate current time division multiple access [TDMA], technology. At present, the majority of our circuits are dedicated, point to point, connections between two geographic locations. This approach does not meet changing communications needs.

The TDMA technique allows time sharing of communications capability among users in accordance with workload demands. The TDMA system will provide for NASCOM operations traffic between user sites. A Program Support Communications Network [PSCN], also utilizing the TDMA technology will handle NASA's nonoperational communications needs among its centers. These services include voice, management and administrative traffic, and technical data interchange.

In the mission control and data processing areas which include spacecraft control and command, data capture and retrieval, flight dynamics, and command generation, we will continue to place emphasis on the completion of the control center for the Hubble Space Telescope to meet support requirements for the 1986 launch. The large software programs required for proper spacecraft operation will be completed and fully tested during this period.

For our Advanced Systems Program, we are requesting $16 million. This small, but vital portion of our program provides studies and technological developments needed to meet future mission support requirements for both manned and unmanned space missions in a reliable and cost-effective manner.

Space tracking and data support to meet the requirements of the space station era are now being evaluated and definition studies will continue through 1986.

In summary, I would again like to mention that we are continuing the transition from a ground tracking network to a space tracking capability for low Earth orbit missions. With the launching of the next two tracking and data relay satellites in 1985, and the completion of required checkout and testing, the TDRSS will achieve full operational capability. We are looking forward to reaching this important milestone. An extremely busy year for the Deep Space Network will be 1986 as it provides major mission support to numerous exciting NASA programs.

The funding level of $824 million requested for 1986 provides the resources necessary to meet the operational support requirements of NASA programs. This budget assumes the successful launches, checkout, and testing of the next two tracking and data relay satellites in order to bring the TDRSS to full operational capability and to allow us completion of the ground station closeout.

Mr. Chairman, and members of the subcommittee, this concludes my shortened statement. I appreciate this opportunity to discuss our program. I wish to thank the subcommittee for its past support to this important part of NASA's program and to urge the full support of the subcommittee for this 1986 budget request.

I would be happy to answer any questions you may have at this time.

[The prepared statement plus answers to questions asked of Mr. Aller follow:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

STATEMENT OF

ROBERT O. ALLER

ASSOCIATE ADMINISTRATOR FOR

SPACE TRACKING AND DATA SYSTEMS

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications

Committee on Science and Technology

House of Representatives

Mr. Chairman and Members of the Subcommittee: Thank you for this opportunity to present the FY 1986 budget request for the Space Tracking and Data Systems Program.

As discussed last year, the Space Tracking and Data Systems Program is in the process of transitioning from a totally ground based network to a space based tracking capability augmented by ground stations for deep space tracking of interplanetary vehicles. This transition began with the launch of the first Tracking and Data Relay Satellite (TDRS-1) in April 1983. The required satellite constellation will be completed with the launches of TDRS-2 and TDRS-3. In early March of 1985, TDRS-2 is scheduled to be launched on STS-51E followed by the launch of TDRS-3 later this year. Once the required testing and checkout have been accomplished on both spacecraft and the ground terminal, full operational capability for the Tracking and Data Relay Satellite System (TDRSS) will have been achieved.

In anticipation of the TDRS era, we continue to make substantial reductions in our tracking network that supports near-Earth orbit spacecraft. The Spaceflight Tracking and Data Network (STDN) is about one half the size it was five years ago, and most of the other stations will be closed or transferred to other agencies when TDRSS becomes operational.

The major upgrade underway to the Deep Space Network is scheduled for completion in the fall of 1985. This upgrade was necessary to permit us to meet increasingly complex mission needs to support spacecraft exploring the limits of our solar system. A critical milestone for this activity is to ensure the capability of the DSN to support Voyager 2's Encounter with the planet Uranus in January 1986.

The Communications Program is also in a transition phase as it provides for Agency communication links for both operational and administrative communications support.

I plan to discuss these elements in detail, but first, I would like to quickly highlight activities during the past year.

HIGHLIGHTS

Significant accomplishments were achieved in our Space Tracking and Data Systems Program. The first Tracking and Data Relay Satellite (TDRS), launched on the STS-6 in April 1983, successfully supported five Shuttle missions in 1984, in addition to providing support services for Landsats 4 and 5, Spacelab, Earth Radiation Budget Satellite (ERBS), Solar Maximum Mission (SMM), and Solar Mesosphere Explorer (SME). At the same time, extensive acceptance testing has been completed.

The ground networks provided support to both near-Earth orbit satellites and deep space missions, as well as to balloons, sounding rockets and aeronautics flight test programs. The focus of the Spaceflight Tracking and Data Network (STDN) was primarily on Shuttle support, but it did actively support about a dozen other missions including the Landsat, Active Magnetospheric Particle Tracer Explorer (AMPTE) and Earth Radiation Budget Satellite (ERBS) launches. The Deep Space Network (DSN) supported the continuing exploration of interplanetary space by spacecraft in the Voyager and Pioneer series. It also took over the responsibilities for the newest interplanetary probe, the International Cometary Explorer (ICE), which is now well on its way to an encounter with the Giacobini-Zinner Comet in September 1985. In addition, the DSN's activities extended to the lower Earth region when it was the lead network in supervising and managing support for the Active Magnetospheric Particle Tracer Explorer (AMPTE) mission launched in August 1984. In the Aeronautics, Balloon and Sounding Rocket area, a major activity was the support for the Controlled Impact Demonstration aircraft crash in November.

Two major elements in NASA's Communications Program were initiated in 1984, both of which will employ available advanced technologies developed by the communications industry. One, a Time Division Multiple Access (TDMA) system will provide operational circuits via satellite which can be readily configured to conform with communications capability among NASA facilities as a function of dynamic workload requirements. The second, a Program Support Communications Network (PSCN) will handle NASA's growing non-operational communications needs among its Centers. These services include voice, management and administrative traffic, and technical data interchange.

Of particular note, during 1984, was the demonstration by NASA of the recovery and repair of the Solar Maximum Mission. Due to operational difficulties, this became an extremely complex undertaking. Members of the tracking and data program Attitude Computation Team essentially worked around the clock to analyze the problem, develop the solution, and generate over 300,000 commands which allowed the spacecraft to be stabilized and retrieved.

Preparation for the ground control center and data capture facility for the Hubble Space Telescope continues on schedule. Initial tests have been successfully completed between the Hubble Space Telescope Operations Control Center and elements of the Hubble Space Telescope spacecraft.

Having reviewed some of the major highlights of our program since our last hearing, I will now turn to our significant accomplishments, budget request, and the challenges ahead.

FY 1986 BUDGET REQUEST

We are requesting a total of $824.5 million for FY 1986 to continue to provide tracking, command, data acquisition and data processing support to ongoing NASA flight projects and for extensive preparations to support upcoming missions. Our budget represents funding to provide services and to operate our networks and other facilities in support of flight programs.

The increase from the current FY 1985 budget to the FY 1986 request is principally due to a $30 million prepayment on the outstanding Federal Financing Bank (FFB) loans extended to finance the TDRSS Program. This prepayment will reduce the total interest cost on the TDRSS loans and reduce the total program runout.

When excluding the prepayment and allowances for inflation, the FY 1986 dollar level, by comparison, would be more than $40 million below the FY 1985 budget.

It should be noted that this budget assumes the successful launch and checkout of TDRS-2 scheduled for March and TDRS-3 scheduled later this fiscal year.

The subsequent portion of my statement addresses our various programs in more detail.

SPACE NETWORK

I would like to first briefly review with you the Space Network elements and their functions.

The Space Network consists of the Tracking and Data Relay Satellite System (TDRSS) and the associated NASA ground systems necessary to provide support services to low-Earth orbital spacecraft compatible with the TDRSS. The primary elements of this network are the Tracking and Data Relay Satellites, the contractor and NASA ground terminals at White Sands, New Mexico, and the ground control facilities at the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. The TDRSS satellites and the White Sand Ground Terminal (WSGT) provide the communications between the ground and user spacecraft in both command (forward) and telemetry (return) modes. Other elements of the network interconnect the ground control facilities of the user spacecraft with the TDRSS. Specifically, the NASA Ground Terminal (NGT) monitors TDRSS performance and performs trouble shooting and system verification functions for the network. The Network Control Center (NCC) schedules TDRSS services for all users and serves as the focal point for user interaction with TDRSS. The Flight Dynamics Facility (FDF) provides orbit determination and time correlated position location for all Earth orbiters. The Bilateration Ranging Transponder System (BRTS) provides precision position location for the TDRSS satellites. The Simulations Operations Center (SOC) and Compatibility Test Vans (CTV) provide necessary testing, simulations, and interface verification for the user spacecraft and Space Network elements to assure operational readiness prior to the launch of a given mission.

In FY 1986, we are requesting $400.8 million for the Space Network Program. This year, we plan to complete the three satellite configuration and establish the operational system. Two operating satellites will be in place, one at 41 degrees West Longitude and the other at 171 degrees West Longitude. The third satellite will be stationed as an on-orbit spare. The funding being requested for FY 1986 will provide for the completion of the TDRSS on-orbit network; for the maintenance and operation of the operational system; enhancements to that system to provide more reliable service; and the annual payments to the Federal Finance Bank (FFB).

During this past year, we have made significant progress toward the realization of the operational Space Network. TDRS-1 successfully supported five Shuttle missions in 1984, and one in January 1985. In addition, the Solar Maximum Mission (SMM) and Spacelab missions were supported as well as continued support provided to Landsats 4 and 5, the Earth Radiation Budget Satellite (ERBS), and the Solar Mesosphere Explorer (SME). Extensive acceptance testing was completed with TDRS-1. This testing revealed that the spacecraft operated as designed (with the exception of the Ku-Band failures which I reported to you last year); however, as was expected, numerous operational problems were encountered at the White Sands Ground Terminal. These problems have been or are now in the process of being corrected.

The second satellite, TDRS-2, is scheduled for launch on Space Shuttle mission, STS-51E, in early March 1985. Operational tests will follow and acceptance testing is expected to be completed and the satellite in its operating position about mid 1985.

In addition to the system testing, we have also modified spacecraft 2 through 6 to correct the problems which caused the Ku-Band failures on TDRS-1 and have modified the C-Band antenna.

Production of the remaining four satellites is continuing; TDRS-3 is essentially complete and TDRS-4 will start final buildup in March and will be placed in storage upon completion. TDRS-5 and -6 will be placed in storage in modular form. As these spacecraft are needed as replacements, they will be removed from storage, assembled, and tested prior to launch.

While the operational Tracking and Data Relay Satellite (TDRS) system must await additional testing of the ground terminal in conjunction with the second and third spacecrafts, we have made significant progress in the past year toward the goal of achieving an operational Space Network. During FY 1986, we plan to achieve that goal.

GROUND NETWORKS

We are requesting a total of $219.3 million to meet the Ground Networks support requirements in FY 1986. The Ground Networks will consist of the Spaceflight Tracking and Data Network (STDN), the Deep Space Network (DSN), and ground tracking and data acquisition support for the Aeronautics, Balloons, and Sounding Rocket Programs. In FY 1986, we will look forward to continuing the support of NASA flight projects, both in the near-Earth region and in deep space. Phase out of the majority of the present Spaceflight Tracking and Data Network (STDN) ground stations should occur in this time frame.

FY 1986 will be an extremely busy year in the Deep Space Network (DSN) history with major mission support periods throughout the year. Support for the International Cometary Explorer (ICE) mission will continue after its encounter with the Giacobini-Zinner comet in September 1985, and launch support will be provided for the Geosynchronous Operational Environmental Satellite-G (GOES-G) weather satellite in October. The network, augmented by non-NASA facilities, will support the Voyager 2 spacecraft encounter with the planet Uranus in January 1986. Tracking the USSR's two Vega spacecraft for the European Space Agency will occur prior to the March 1986 encounter, as they approach the comet Halley. The data obtained will permit the European Space Agency to improve targeting for their Halley's probe--Giotto. The DSN will also provide backup tracking for Giotto under a reimbursable agreement with the European Space Agency. In May, the launches of the Galileo and Ulysses spacecraft will be supported as they start their journeys to Jupiter, and in August, the launch of the Geosynchronous Operational Environmental Satellite-H (GOES-H) will be supported. This support, discussed above, will be in addition to the continuing support of man's only spacecraft exploring the outer solar system--the two Voyagers and Pioneers 10 and 11--as they seek the limits of our solar system. Pioneer 10, which is the most distant spacecraft, is so far from Earth that our radio signals must travel almost five hours to reach it!

SPACEFLIGHT TRACKING AND DATA NETWORK (STDN)

When TDRSS achieves its operational status, the STDN will be reduced to a minimum capability early in FY 1986. Of the 11 active STDN stations today, there should only be two remaining by late next year. Merritt Island, Florida, and Bermuda will be primarily involved in Shuttle launch, landing, and pad operations. As we recently notified you, a decision has been made to consolidate support of the International Ultraviolet Explorer (IUE), Nimbus-7, Interplanetary Monitoring Platform (IMP-8) and the Cosmic Background Explorer (COBE) missions at Greenbelt with the Aeronautics, Balloons, and Sounding Rocket (AB&SR) facility at Wallops Island. This action will permit us to close the Greenbelt, Maryland, STDN station in addition to the previously planned closures.

Under current plans, the other stations will cease operations with the successful launch and checkout of the next two Tracking and Data Relay Satellites. Most of these stations will be closed and a few will be transferred to other agencies. Since my last testimony, we closed the Botswana Shuttle air-to-ground voice station and transferred our Alaska tracking station to NOAA.

We are also in the final stages of our Network Consolidation Program with completion scheduled for the end of February 1985. At three locations (Goldstone, CA; Madrid, Spain; and Canberra, Australia) there were separate antenna facilities for the STDN and DSN stations. The program which we have implemented consolidates all facilities at the Deep Space Network stations under the single management of the Jet Propulsion Laboratory (JPL). This has enabled us to close the two STDN stations in Australia and Spain.

Our FY 1986 request for STDN operations and maintenance is substantially less than our FY 1985 request, which reflects the planned phaseout of the stations. If there is any further delay in achieving the full TDRSS operational capability, some or all of the current ground stations may have to be extended beyond the planned phaseout period which may require an increase in network and communications funding to support such an extension.

DEEP SPACE NETWORK (DSN)

The Deep Space Network (DSN) supports planetary and interplanetary flight projects. The major objective is to provide responsive, but cost-effective, communications and navigation of scientific spacecraft on the outer reaches of the solar system as well as tracking and communications with those Earth orbiting spacecraft that cannot be supported by the Tracking and Data Relay Satellite (TDRS). The network will also be able to provide emergency support for spacecraft such as the STS, the TDRSS, and the Hubble Space Telescope, as well as permit extending the productive life of several older spacecraft. DSN facilities are also used in related scientific research, such as the study of planets and comets through the use of radar techniques, the search for the existence of gravity waves and extraterrestrial intelligence, as well as mapping of locations of extragalactic radio sources for use in precision interplanetary navigation.

The DSN upgrade is proceeding very well and will be completed by 1986. As you may recall, this upgrade will give us a modern, efficient ground network with new capabilities to combine signals from several antennas to obtain more scientific data. The most pressing need for this capability is to receive more images from Voyager as it encounters the planets Uranus in January 1986, and Neptune in 1989. Construction is now complete on the new 34-meter antennas in California and Australia to increase the capability of the DSN to support these encounters as well as other DSN missions.

At Madrid, construction of the third 34-meter antenna has begun, as well as actions to convert the 64-meter antenna to 70-meters, which will allow greater data gathering capability at that location.

The DSN is on the threshold of an especially active and critical period. It will be the key participant in an international network to obtain atmospheric data from Venus during the Vega Encounter in June. Then, in September of this year, the DSN, supplemented by the Arecibo Radio Telescope Facility of the National Science Foundation, will obtain data from the first encounter of a comet by a spacecraft--the International Cometary Explorer's Encounter with the comet Giacobini-Zinner.

During the Uranus Encounter in January 1986, which will occur almost 3 billion kilometers from Earth, Voyager 2 will transmit the first detailed images ever made of that planet, its rings, and its moons. To achieve the full potential of this encounter, the DSN must successfully array multiple antennas. In Australia, this will include the use of the 64-meter antenna of the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO).

Following the Uranus Encounter, the Voyager-2 spacecraft will be targeted to arrive at the Planet Neptune in August 1989. Preparations for support of the Neptune Encounter will include, in the FY 1986 construction program, an expansion of the 64-meter antenna to 70-meters at Goldstone and Canberra. These upgrades are also required for Galileo, to track the ever more distant Pioneer 10 spacecraft after 1992, and to accommodate the anticipated workload. In addition, we will initiate actions with the National Science Foundation to modify their Very Large Array Antennas in New Mexico so they may be arrayed with Goldstone to support the Voyager Neptune Encounter. As previously mentioned, the DSN will participate in the Halley's Comet investigations in March, and the launches of Galileo and Ulysses as they begin their trips to Jupiter and beyond.

Highlights of the FY 1986 budget include beginning the implementation of an X-band uplink capability at each DSN complex as required for Galileo support and a higher data rate capability required for the Venus Radar Mapper mission. In addition, 1986 will mark the beginning of an upgrade of the DSN Network Operations Control Center at Pasadena, California, to accommodate the significantly higher network scheduling and monitoring activity projected for the 1988 - 1990 period.

AERONAUTICS, SCIENTIFIC BALLOONS, AND SOUNDING ROCKETS

Another important activity of our Program is the tracking and data acquisition support to the Aeronautics, Balloons, and Sounding Rocket activities managed by the Ames Research Center (ARC) and the Goddard Space Flight Center (GSFC). Over the years, our facilities have developed into a comprehensive suborbital flight support capability encompassing the complete spectrum of fixed and mobile ground support functions including telemetry, communications, optics, command, space positioning and data processing. For sounding rocket missions, we also perform vehicle and payload impact prediction and range surveillance functions in support of range safety.

In 1984, the Goddard Space Flight Center's (GSFC) Wallops Flight Facility (WFF) supported 150 rocket launches, 160 balloon launches, and 260 aeronautical research missions. At Ames Research Center (ARC), we began the integration of the Moffett Field, Crows Landing and Dryden Flight Research Facility activities into a consolidated Western Aeronautical Test Range. At ARC, we supported about 400 missions in 1984. Support increased not only in terms of the duration of individual flights, but also in the number of parameters monitored.

Our FY 1986 budget request includes funds to maintain our current level of support and accommodate anticipated operational cost increases. We propose to continue on our long range plan for systematic upgrade of equipment as requirements and efficiency dictate.

COMMUNICATIONS AND DATA SYSTEMS

In FY 1986, we are requesting a total of $188.2 million for the Communications and Data Systems Program. The basic elements of this program form the vital link between the data acquisition stations and the users and include communications, mission control, and data processing. This program is also in a state of transition with major developments and augmentations in process.

COMMUNICATIONS

The Space Tracking and Data Systems Communications Program provides communication services for the Agency wide operational and administrative communications needs. Collectively, the NASA networks comprise almost 3 million miles of circuits with associated switching and terminal facilities. A global system interconnects NASA's foreign and domestic tracking and data acquisition station, launch areas, and mission and network control centers, NASA field installations, and some contractors.

Two major changes are being introduced in the 1985/1986 time frame. A Time Division Multiple Access (TDMA) system is being incorporated as part of the NASA communications network which provides operational support to NASA missions. It will provide more effective use of communications satellite transponders, and will improve services throughout the Agency.

A second activity is the development and implementation of a coordinated network to meet NASA's administrative traffic as well as voice and data interchange. At present, this service has been provided through a series of requirements levied individually on the Marshall Space Flight Center (MSFC) which has the overall responsibility of providing this administrative communications service. By consolidating these many requirements into a single design of a coordinated network, the rapidly increasing communications workload can be met more effectively and economically. In FY 1985, the Office of Space Tracking and Data Systems (OSTDS) is contracting for the development, implementation, and operation of this single network.

Both of these activities will become operational in FY 1986. Since nearly 100 percent of the services and systems which comprise NASA's communications activity are leased, the great majority of the funds requested in FY 1986 are to meet the lease costs for continuing the operation and maintenance of these vital communications services.

MISSION CONTROL

The Mission Facilities Implementation Program provides the systems capability to command and control NASA's unmanned scientific and applications satellite program through Payload Operations Control Centers (POCC's) and related Mission Support Systems (MSS) which receive, process, and display spacecraft telemetry data and transmit commands. Currently, four control centers monitor and control some 9 spacecraft. Funds are required in FY 1986 to operate these control centers and supporting facilities for the control of on-orbit missions.

We will continue to place emphasis on the completion of the control center for the Hubble Space Telescope so that the currently scheduled 1986 launch can be supported. In FY 1986, this will require funds to complete and acceptance test the large software programs required for proper spacecraft operation. These programs, consisting of some one million lines of code, manage the major operational activities of the mission including monitoring spacecraft and subsystem health and safety, pointing the observatory at selected sources, pointing the spacecraft antenna at the TDRS, conducting mirror surface calibrations, and focusing the mirror itself.

Also included in the FY 1986 request are funds for modifications to the existing Multisatellite Operations Control Center (MSOCC) for control of the upcoming Gamma Ray Observatory (GRO), the Cosmic Background Explorer (COBE), the Upper Atmosphere Research Satellite (UARS), and initiation of development activities for the Solar Optical Telescope (SOT).

DATA PROCESSING

Two separate activities are funded within the Space Tracking and Data Systems Data Processing Program. These include processing of data acquired by the low Earth orbiting spacecraft for both scientific and applications missions, and real time computation support of mission operations which includes attitude determination and command management. Included in this request are funds to complete the system replacement for the major computational elements. The large data processing systems at GSFC, which provide support to low Earth orbiting missions have been replaced over the past several years. During FY 1986, resources are necessary to replace much of the peripheral equipment associated with these large computers and to adapt the large complex application software into these new computers. Upgrading of these software programs will take advantage of the increased capabilities available within these new machines and result in reduced operational costs.

In FY 1986, telemetry data processing support continues for the ongoing free flying NASA spacecraft such as the International Sun Earth Explorers (ISEE), Dynamic Explorers (DE), and the Interplanetary Monitoring Platform (IMP). Planning, systems implementation, and testing will continue for support of new missions such as Cosmic Background Explorer (COBE), Gamma Ray Observatory (GRO), Upper Atmosphere Research Satellite (UARS), and Hubble Space Telescope, future Spacelabs, the ASTRO series, Earth Observations Missions, Solar Optical Telescope (SOT), and Sunlab. Experience gained in supporting the first Spacelab mission and the increased workload based on Spacelab mission requirements dictate the Spacelab Data Processing Facility augmentation.

ADVANCED SYSTEMS

We are requesting a total of $16.2 million for our Advanced Systems Program in FY 1986. This program is a small, but vital portion of the Space Tracking and Data Systems Program. Its studies and technological developments are needed to aid in our planning and to assure reliable and cost effective future support of both manned and unmanned missions. This effort has provided the technological basis for most of the capabilities we are now using, such as X-band telemetry, arraying of large antennas in the Deep Space Network (DSN), extremely low noise receivers, 400 kilowatt transmitters, real time telemetry data processing and the current Tracking and Date Relay Satellite System.

Both in our program and in the market place, computing and communications technology are undergoing rapid change. We must continue to examine the applicability of these advancements to our future program needs. At the same time, many of the activities being undertaken by our program can also reduce risks and costs in the area of space commercialization; e.g., developments aimed at faster and more cost-effective data processing systems; more commonality in spacecraft and ground hardware, greater spacecraft autonomy and reduced vulnerability of microcircuitry to radiation.

CONCLUSION

In summary, we continue in the process of transition from a ground tracking network to a space tracking capability for low Earth orbit missions. With the launching of the next two Tracking and Data Relay Satellites in 1985, and the completion of required checkout and testing, the TDRSS will achieve full operational capability. Once we have reached this important and exciting milestone, remaining station closures or transfers to other agencies will be implemented.

With completion of the Network Consolidation Program in February 1985, the Deep Space Network will assume support responsibility for spacecraft above the view of the TDRSS as well as for those few older spacecraft which are not compatible with TDRSS.

FY 1986 will be an extremely busy year for the Deep Space Network with its major mission support activities throughout the year.

Space tracking and data support for the Space Station era is being evaluated through study efforts which will continue in FY 1986.

The $824.5 million funding level requested for FY 1986 provides the resources necessary to meet support requirements for the Space Tracking and Data Systems Program. This budget assumes the successful launches, checkout, and testing of the next two Tracking and Data Relay Satellites in order to bring the TDRSS to full operational capability and to complete station closures.

Mr. Chairman and Members of the Subcommittee, this concludes my statement. Thank you for this opportunity to discuss NASA's Space Tracking and Data Systems Program. I urge the full support of the Subcommittee for our FY 1986 budget request.

Thank you.

SPACE TRACKING AND DATA SYSTEMS PROGRAM

FUNDING REQUIREMENTS (IN MILLIONS OF DOLLARS)

	FY 85 BUDGET	FY 86 REQUEST
SPACE FLIGHT CONTROL AND DATA COMMUNICATIONS		
• SPACE NETWORK	$378.3	$400.8
• GROUND NETWORK	233.2	219.3
• COMMUNICATIONS AND DATA SYSTEMS	184.2	188.2
SUB-TOTAL	$795.7	$808.3
RESEARCH AND DEVELOPMENT		
• ADVANCED SYSTEMS	$ 14.8	$ 16.2
TOTAL	$810.5	$824.5

FIGURE 1

TDRSS STATUS

SUPPORTING MISSIONS

- SHUTTLE/SPACELAB
- LANDSAT
- ERBS
- SME

CONTINUING GROUND TERMINAL TESTING

- ONE TEST LEFT TO BE COMPLETED
    - REMAINDER MUST AWAIT LAUNCH OF ADDITIONAL SPACECRAFT

LAUNCH SCHEDULE FOR 1985

- TDRSS-2 MARCH
- TDRSS-3 LATER IN THE YEAR
    - FIRM DATE NOT YET AVAILABLE

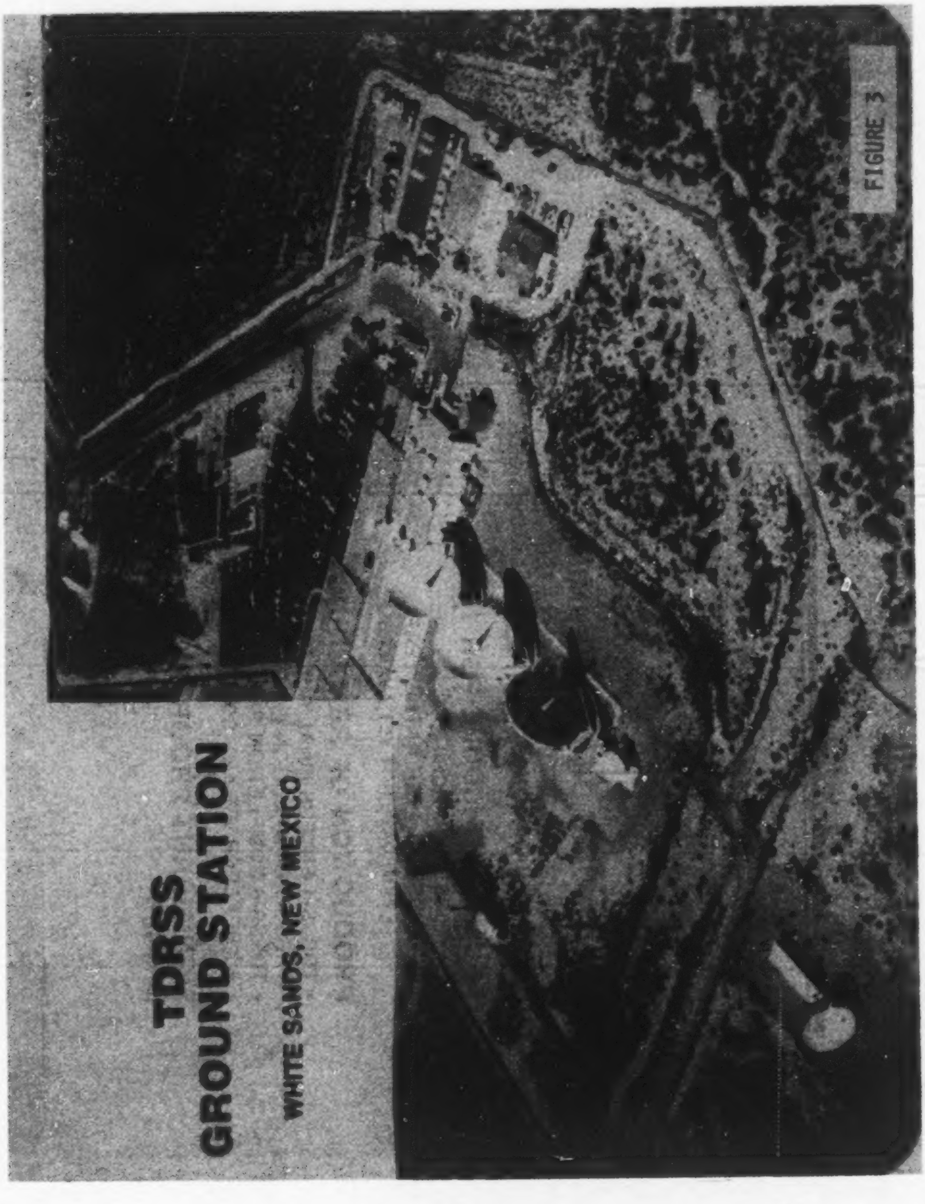
PRODUCTION OF REMAINING SPACECRAFT

- TDRSS-4 ENTERS FINAL BUILD-UP MARCH
- TDRSS-5 COMPLETION LATE 1985
- TDRSS-6 COMPLETION EARLY 1986
- AS SPACECRAFT ARE COMPLETED THEY WILL BE STORED

SIGNIFICANT PROGRESS TOWARD AN OPERATIONAL SYSTEM IN 1985

FILE NAME: TDRSS84

FIGURE 2



TDRSS
GROUND STATION

WHITE SANDS, NEW MEXICO

FIGURE 3

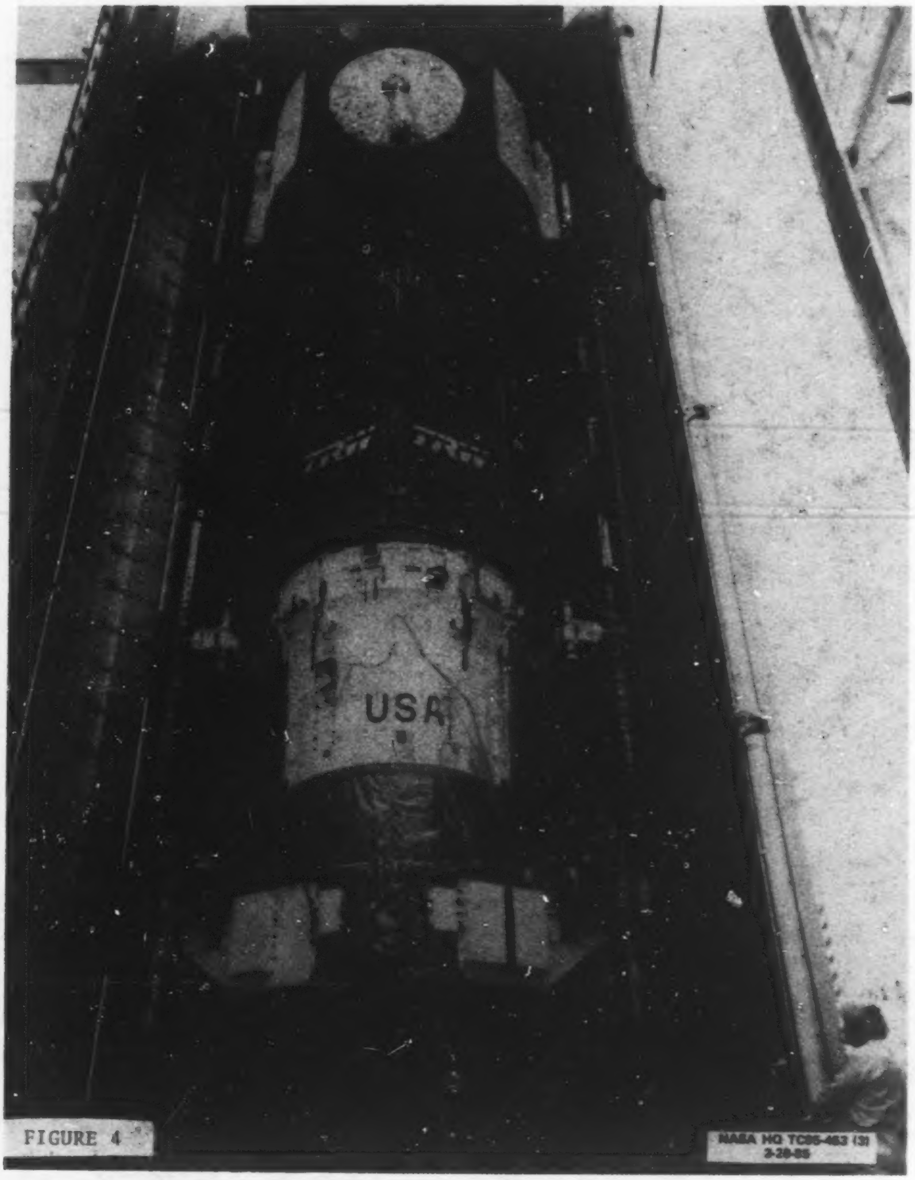
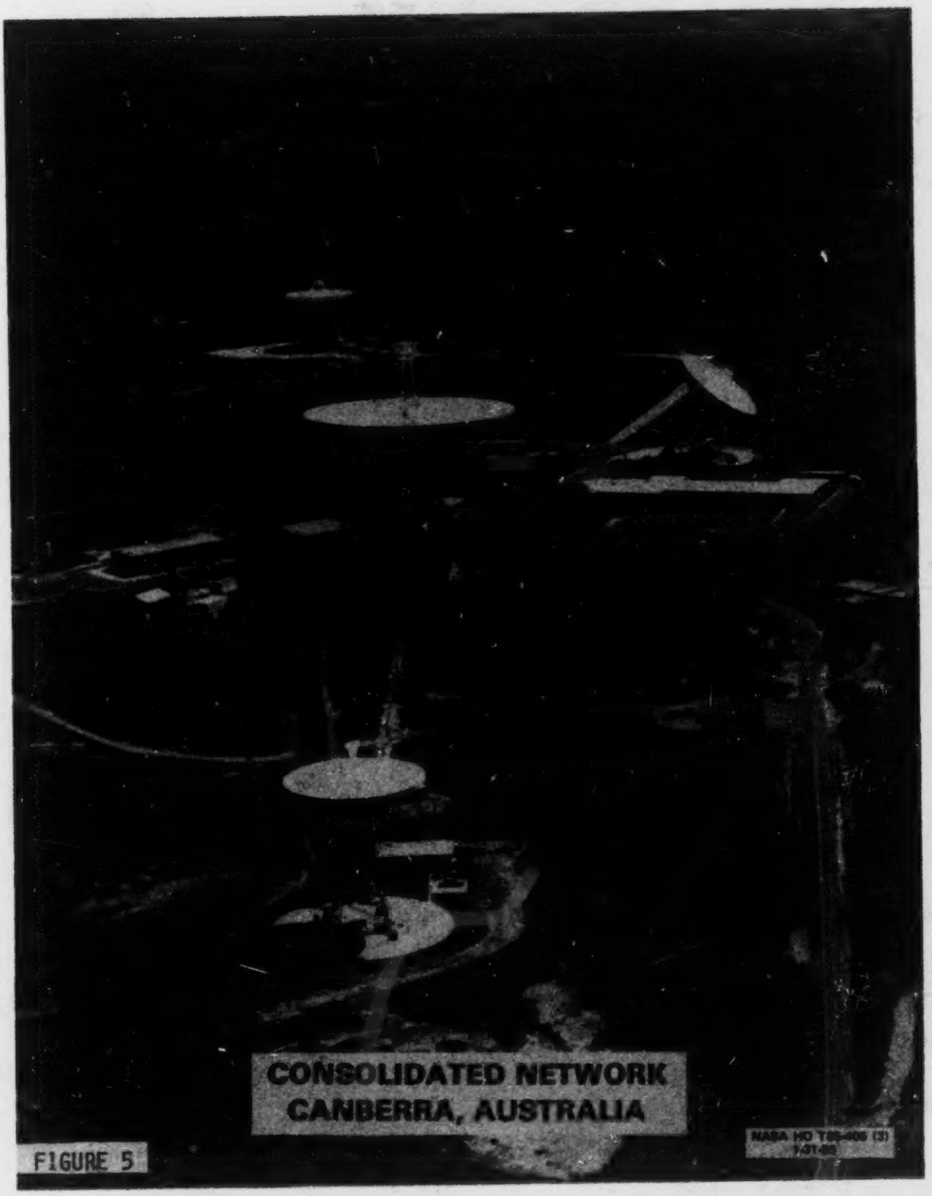


FIGURE 4

NASA HQ TC85-483 (3)
2-28-85



CONSOLIDATED NETWORK
CANBERRA, AUSTRALIA

FIGURE 5

NASA HQ T89-406 (3)
1-31-89

GROUND NETWORK
MISSION SUPPORT PLANS

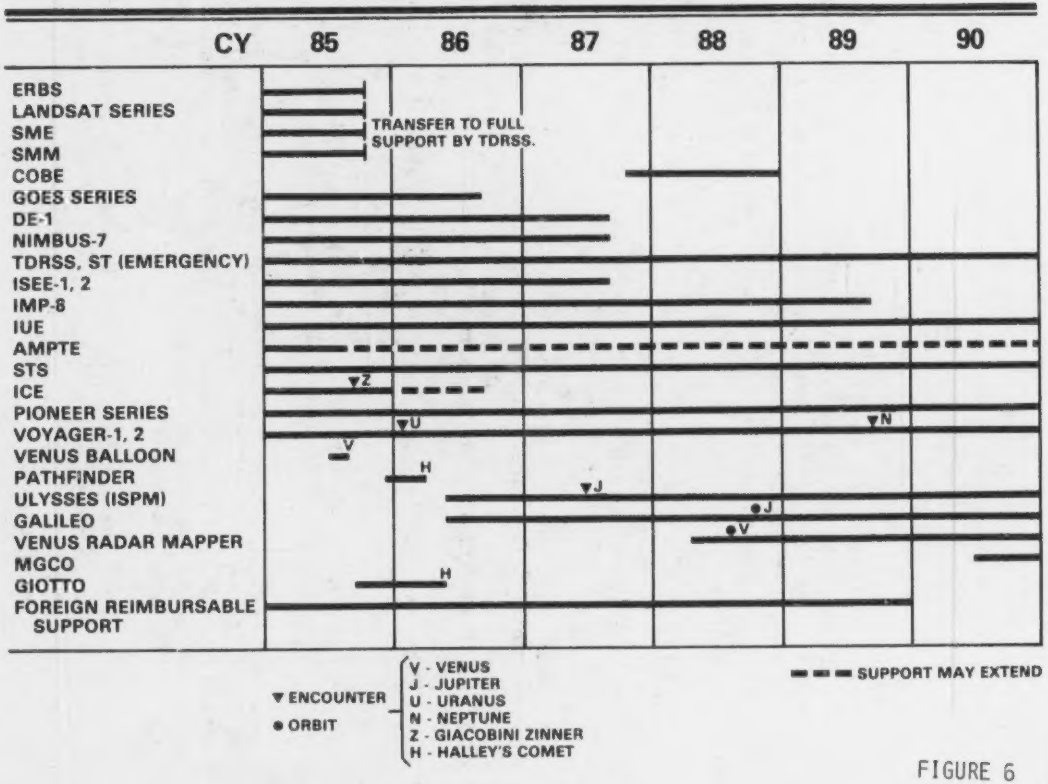


FIGURE 6

QUESTIONS FROM CHAIRMAN NELSON TO
ROBERT O. ALLER DURING THE HEARING ON FEBRUARY 19, 1985

TDRSS TECHNICAL/OPERATIONAL ISSUES

Question T-1:

The Tracking and Data Stellite System (TDRSS) is a complex commuications system that has experienced technical and operational problems which have delayed the system's implementation about five years beyond the original target date (January 1980). NASA now predicts that the system will be fully operational in late 1985.

a. What is the status of the TDRS-A satellite presently in orbit in terms of its capacity to support the TDRSS constellation? From a functional standpoint, how much of its designed capacity does theTDRS-A satellite still have?

b. Does NASA anticipate any delays for technical or other reasons in the scheduled launch dates of the TDRS-B (February 1985) and TDRS-C (3Q 1985) satellites? Have B through F been modified in response to the problems on A?

c. When is NASA projecting the TDRS system to reach full operational status?

d. What impact, if any, will the slippage in the TDRS project have on the "useful" life of the TDRS system?

e. Has construction and environmental testing been completed on the final three TDRS satellites which will be placed in ground storage? Will the Federal Financing Bank be advancing any additional loans for any aspect of the TDRSS project? If so, how much and for what purpose?

f. If the three-satellite TDRSS constellation becomes operational later this year as planned and assuming normal system degradation, what will be the likely deployment schedule for the TDRS satellites presently in storage?

g. Outline the progress that is being made to integrate the Tracking and Data Relay Satellite System (TDRSS) and the Deep Space Network into a single network supporting geosynchronous, highly elliptical and planetary missions. When will this integration process be completed?

h. Are the ground elements of the TDRSS system such as the White Sands Facility, Network Control Center, etc., coming on stream smoothly?

Answer T-1:

a. TDRS-A has one failed K-band forward (command) link of the two links available and one failed Traveling Wave Tube Amplifier (TWTA) on the second link, leaving the second link operable but with no redundant TWTA. It has also experienced some thruster failures, but these do not impair its operational capabilities once on station. Maneuvering the spacecraft without a full complement of thrusters is more difficult, but can be accomplished. From a functional standpoint, the K-band failure allows the satellite to support only one user at a time in the high data rate command mode. However, the S-Band command link is fully operable and has been capable of meeting all user requirements to date.

b. The launch of TDRS-2 has been deferred due to a problem in the timing circuits of the spacecraft. The extent of the delay required to complete the modifications is not yet known. There was also a battery problem encountered with this spacecraft. The schedule for the launch of the third spacecraft is likely to be affected as well.

All the remaining satellites have been modified to correct the thruster and K-band failures on TDRS-A and will be modified as necessary to correct the timing circuits and battery problems found on TDRS-B.

c. NASA is projecting full operational status for the TDRSS after the third spacecraft has been launched and checked out.

d. The delays have not diminished the anticipated "useful life" of the system. We anticipate a full ten years service from the system, perhaps more.

e. The construction and testing of the fifth and sixth spacecraft will be suspended at the modular level to provide easier,lower cost maintenance during storage. The fourth spacecraft will continue construction and testing to be launched as early as late 1986.

No further FFB loans will be extended for TDRSS. The advances on the loans were terminated last September.

f. Our storage plans assume the fourth spacecraft may be launched as early as late 1986. We project the fifth and sixth spacecraft launches to be required in late 1988 and 1990 respectively based on analysis. The launches of these last two spacecraft will not occur, however, until they are required.

g. The Spaceflight Tracking and Data Network (STDN) is the network being consolidated with the DSN, not the Space Network which includes the TDRSS. The integration of the STDN and the DSN under the Network Consolidation Program was completed at the end of February 1985.

h. The elements of the Space Network are on-line and the TDRSS has been supporting STS and other missions such as Spacelab and Landsat even though we are not fully operational. We have encountered some problems at the White Sands Ground Station in reaching this posture; however, in initiating the operation of any new complex system, such problems are to be expected.

Question T-2:

As NASA converts to the TDRSS system, its communication with spacecraft becomes more centralized.

a. Is there a chance for a bottleneck developing? Does all the data have to go through one point?

b. Several ground stations will close down as part of the conversion to TDRSS, but the Deep Space Network (DSN) will be kept open. Will the DSN have the capability to track Earth orbiting satellites and thus provide a backup to TDRSS?

Answer T-2:

a. As Earth-orbital missions convert to TDRSS support, centralization does occur and all data does come through a single facility at White Sands. However, the systems are designed to provide inherent redundancy, both in the spacecraft and ground systems to prevent a single point of failure. The White Sands ground terminal, for instance, has three complete chains of ground equipment to support a two satellite data flow so that a spare chain is always available should a failure occur. The system is vulnerable to a total site failure.

b. The DSN is equipped with the capability to track Earth orbiting satellites, and will be able to provide backup support limited to maintaining the health and safety of the spacecraft.

Question T-3:

To help us understand your workload, how many satellites are you now tracking, communicating with, and receiving data from?

Answer T-3:

The networks are presently supporting 34 satellites, 12 of which are only receiving periodic support.

CONSOLIDATION/ELIMINATION OF GROUND STATIONS

Question T-4:

Once the Tracking and Data Relay Satellite System (TDRSS) becomes operational, NASA will eliminate six of eleven ground stations which presently provide communications support for NASA's low-Earth orbital missions. The elimination of ground stations will save NASA approximately $50 million in annual operating expenses associated with this ground network.

a. What is NASA's schedule for phasing out ground stations?

b. Which ground stations will be eliminated?

c. What are the consequences of this elimination program to ground station personnel employed by NASA?

d. What will be the disposition of the stations that are eliminated from the network and the equipment located at those stations?

e. How will the annual cost of the TDRS system (include operating and amortized production costs) compare with the STDN ground station network?

f. The ground stations generate political benefits for the U. S. Space Program in their host countries, thus closing them will have a political cost. How and where are these political costs weighed?

Answer T-4:

In anticipation of the TDRSS era, we have been and are continuing to make substantial reductions in our ground tracking networks as support requirements permit. The operation of the Spaceflight Tracking and Data Network has been reduced by about one-half over the past five years with the closure of stations in Winkfield, England; Rosman, North Carolina; Quito, Ecuador; Fairbanks, Alaska; Buckhorn, California; and Gabarone, Botswana.

a. NASA's schedule for phasing out ground stations is dependent upon achieving an operational capability with TDRSS. Final phasedown will begin about 90 days after the launch and checkout of the third TDRS satellite.

b. The Ground Stations that will be eliminated are as follows: Guam; Hawaii; Ascension Island; Dakar, Senegal; Santiago, Chile; and the air-to-ground voice station in Yarragadee, Australia.

c. The ground stations are operated almost completely by contractor or foreign national personnel. Only one direct NASA employee--a representative in Chile--remains at the station which will be closed. Ground station personnel at Guam, Hawaii, Ascension Island and Dakar are employees of the Bendix Field Engineering Corporation. The company has been aware of the phasedown plans for several years and will try to absorb as many people as possible into other parts of their company. Bendix has been very successful in accommodating their personnel from stations recently closed. At Santiago, Chile, the employees belong to the University of Chile which is planning to operate a satellite tracking station in Chile, so many of the current employees may be accommodated. The air-to-ground voice site in Australia is collocated with our Laser Tracking Station, and the air-to-ground functions have been performed by the same personnel. Hence, there will be little personnel impact.

d. Disposition of stations eliminated from the network will be as follows:

(1) Ascension Island -- Will be transferred to the Air Force Eastern Space and Missile Center for their future use.

(2) Hawaii -- Will be transferred to the U. S. Navy Pacific Missile Test Center and the U. S. Air Force Western Space and Missile Center.

(3) Guam -- Station will be closed and the technical assets transferred to the U. S. Air Force Western Space and Missile Center for use elsewhere. The land will be returned to the

current lease holder.

(4) Santiago, Chile -- In accordance with Government regulations, the station will be donated to the University of Chile for their use.

(5) Dakar, Senegal -- This station is primarily contained in two vans which will be closed and the vans returned to the U. S.

(6) Yarragadee, Australia -- Air-to-ground voice equipment will be retained on site for possible emergency use.

e. The inclusion of amortized production costs (TDRSS loan repayments) for TDRSS would not provide a valid comparison of annual operating costs with the STDN since investment costs are not included in the annual operating costs of the STDN. Much of the investment in the STDN occurred in the 1960's largely in response to the Apollo Program.

To obtain a proper basis for comparison, FY 1980 was chosen as the STDN baseline since it was the last year that reflected a full 16 station network and is representative of the station complement that would have been retained if TDRSS had not been approved. For the Space Network, the FY 1986 budget level was used, excluding the TDRSS loan repayments of $257 million, since it represents a full operating level for that Network. In both cases, the elements of cost included maintenance, operation, unique communication circuit costs and minimal sustaining activity. Also, the FY 1980 costs for the STDN were adjusted to FY 1986 dollars for a proper comparison.

Using the above ground rules, including the conversion to FY 1986 dollars, the annual STDN costs were $187 million as compared to $149 million for the Space Network. Aside from the relative cost advantage in annual operating costs of 20% for the Space Network in this comparison, it should be noted that other benefits will be derived from an operational TDRSS. These include a virtually continuous capability both for transmitting data at extremely high data rates and for emergency spacecraft support with TDRSS as contrasted with a capability available about 15% of the time using a full ground network.

f. In all instances, we have coordinated our phasedown plans with both the State Department and the U. S. Embassies in the countries involved. This coordination has been taking place for several years. There has not been any adverse reaction from our host countries during this period and we foresee none during the phaseout period. Careful coordination and planning has, in our view, avoided any negative political costs.

FUTURE SPACE COMMUNICATIONS ISSUES

Question T-5:

The Tracking and Data Relay Satellite System (TDRSS) is designed to be the primary means of providing tracking, communication and data processing support to low-Earth orbit space missions including the Space Shuttle and planned Space Station. the TDRS system is projected to provide communications support through 1993. Once the TDRS system becomes operational, 13 years will have passed between the conceptual and implementation stages of the project, suggesting long lead times are needed to adequately plan for NASA's future space communications capabilities.

a. Given that NASA's schedule of missions is becoming increasingly complex, how will the communications capacity of a fully operational TDRS system balance out against NASA's overall mission requirements in the late 1980's/early 1990's and during the Space Station period?

b. There is some talk that the Space Station might require additional communications access links over and above the capacity of TDRSS. If this is a potential problem, how is it being planned for? Is it part of the Space Station program?

c. What portion of NASA's FY 1986 budget, under the "Advanced Systems" category or other budget categories, is earmarked for the development of the "next generation" TDRS system?

- Can you provide any information as to what that system might look like from an operational standpoint?

- When does NASA plan on requesting some level of project funding for an advanced communications system project?

d. What level of mission support is being requested from non-NASA sources (i.e., foreign, commercial, government agency)? How are requests from these user groups likely to grow in the future? How are reimbursement rates calculated?

Answer T-5:

a/b. We are currently studying future mission requirements to insure that appropriate support capability exists in the 1990's. Based on initial assessments, we may exceed the capacity of the current TDRSS configuration for the early 1990's. In that case we should undertake to augment that capacity with additional spacecraft of comparable capabilities along with additional ground capability. Funding for this augmentation would be required in the late 1980's. Our assessment is that this initial augmentation would see us through the 1990's and the initial deployment of the Space Station. This era would be followed by the deployment of an advanced system to replace the TDRSS.

c. In the FY 1986 budget, $1.75 million is planned for system studies and further investigation of key, long lead time technologies which might be used for an Advanced TDRS System in the late 1990's.

The system would improve current TDRSS capabilities. Current studies are focused on a two spacecraft configuration with one on-orbit spare. A cross link between relay spacecraft would eliminate blind spots and allow a single U. S. control station for the system. Our studies include the investigation of direct down links to data processing centers, and laser communications for user spacecraft and to provide the cross link between relay spacecraft.

Project funding for an Advanced TDRS System would be initiated in the first half of the 1990's.

d. TDRSS is currently supporting only one non-NASA user, Landsat.

We anticipate some increase in non-NASA user support for programs such as foreign Spacelabs, but such use is not expected to constitute a major fraction of the total support.

Reimbursement rates for OSTDS services are formulated to return a pro-rata share of the operational costs and recover fully any additive costs required to support the reimbursable customer. For non-government users, a limited share of TDRS replacement and launch costs are also considered in the development of the rates.

Question T-6:

For the last several years, the Deep Space Network (DSN) has been building capability to support upcoming missions such as Voyager-2, Galileo, and Venus Radar Mapping. Will the DSN reconfiguration be completed in time to support these missions?

Answer T-6:

We anticipate being ready to meet all future mission requirements. We anticipate that the major upgrade of the DSN will be completed on schedule in mid-August to meet the requirements for supporting Voyager 2's encounter with Uranus next January. The primary new capability required for Galileo is an improvement in tracking and navigation accuracy and for the Venus Radar Mapping Mission a capability to handle increased telemetry data rates. This increased DSN capability will be available when required.

TDRSS BUDGET ISSUES

Question T-7:

The TDRS system was originally projected to cost NASA $810 million. Due to a combination of technical problems and project delays, TDRSS will have cost NASA over $2.8 billion when the system becomes fully operational. NASA has paid for program cost overruns without having to request supplemental authorizations through fiscal belt tightening and deferrals of selected procurements.

a. How does the FY 1986 budget allocate funds for the following activities related to TDRSS?

- Technical modifications needed to make the TDRS system operational.
- Construction/testing of TDRSS satellites.
- Annual payments to Federal Financing Bank.

- Annual fees paid to Spacecom for TDRSS services.

- FY 1986 expenses for STDN ground stations operations compared with FY 1985 expense levels.

b. NASA's current fiscal budget (FY 1985) includes funding authorization to get the TDRS system into operational status. In FY 1984, approximately $259 million was budgeted for TDRSS including funds to cover launch cost, and funds to get the system fully staffed and operating. What happens to those funds when there is slippage in the project?

c. For the previous two fiscal years, 1984 and 1985, NASA has requested fees to pay Space Communications Company for TDRS services and yet Spacecom has yet to deliver a fully operational system.

- Does the fee schedule to Spacecom in any way cause Spacecom to share a portion of the financial burden resulting from slippages in the TDRSS program?

d. What has been the estimated impact of TDRSS program slippages on other NASA programs? For example, the SIR-B remote sensing experiment on the Shuttle apparently was not able to transmit the volume of data originally planned for.

e. The most recent six-month delay in the TDRSS project has cost an estimated $50 million in operating costs for maintaining the STDN ground station network. NASA has been able to avoid requesting supplemental authorizations to cover these expenses.

Suppose that a general cut of $15 million in the FY 1986 OSTDS budget request was made by the Committee, where would the Associate Administrator reduce program expenditures by $15 million and still preserve key departmental budget priorities?

Answer T-7:

Cost growth in the TDRSS program from its original projections has been discussed during several Congressional hearings and is a matter of public record. The cost increases have been principally due to a combination of factors which include program growth, interest, Shuttle/IUS delays, and launch vehicle costs.

As you know, most of the funding adjustments in this program were financed through the Federal Financing Bank.

a.(1) Funds are provided in the FY 1986 budget for operational support functions such as depot level equipment maintenance, software maintenance, storage and maintenance of ground spare spacecraft, launch preparations for the fourth spacecraft, initiation of integration with a new upper stage to be used for the fifth and sixth launches, state taxes, reliability enhancements to the ground terminal, and award fees. These various elements total approximately $45 million. In addition, $22 million is included in the budget for maintenance and operation of the White Sands ground terminal.

(2) Construction and testing of TDRSS satellites are expected to be completed for the fifth and sixth spacecraft at the modular level during FY 1985. As noted in the previous answer, the final assembly, test, and launch preparations for the fourth spacecraft is included in the FY 1986 budget. These activities may not be completed as planned due to the effort necessary to correct the problems which led to the deferral of the TDRS-2 launch. The impact of the launch deferral on these activities is not yet known.

(3) The TDRSS loan repayments in FY 1986 are $257 million.

(4) Service payments to Spacecom in FY 1986 are estimated at approximately $12 million.

(5) The FY 1986 expenses for STDN ground stations operations are projected to be $58.7 million as compared with $93.0 million for FY 1985.

b. A slip in the program schedule does not have a significant impact on the spending rate for a given period. Loan payments continue to be made and operation of the Space Network facilities including White Sands continues on a full time basis even with a single TDRS satellite. Costs of the spacecraft subcontractor continue at nearly the same rate since the bulk of the people who assemble and test spacecraft are used interchangeably to also perform launch support services. Consequently, the major impact of a slip is largely in the total program cost due to a possible stretchout of the manufacturing period and in delays in the launch schedules which have resulted in some spending deferrals.

c. Our contract contains provisions for contractor cost sharing in those instances where delays or failure to provide service are attributable to the contractor.

d. There have been impacts to other NASA programs such as Spacelab, but these impacts have not been serious enough to compromise the mission objectives of any of these programs.

e. With reference to the general statement preceding the question in T-7e, the $50 million included not only operating costs for the ground STDN, but also costs associated with the TDRSS Program delay.

As noted in my statement for the record, if the FY 1986 budget request is adjusted for the $30 million prepayment on the TDRSS loans and for inflation then the request is over $40 million below the FY 1985 funding level. Thus, the FY 1986 request has already been adjusted to provide for only minimal mission support.

As mentioned during my February 19 hearing, flexibility exists to allow for a slip in the third TDRS launch as late as November with an attendant delay in station closures through January 1986.

To the extent that the third TDRS launch and related closure dates extend beyond the dates mentioned above, an additional amount of approximately $6 million per month could be required in

FY 1986. We cannot at this time, however, assess the extent to which the TDRS-2 launch deferral will impact this situation.

Given the above considerations and the program priorities for bringing TDRSS on line along with the extensive effort associated with network consolidation, upgrading of the DSN to support the heavy workload, and the preparation for upcoming mission support, such as Galileo and the Uranus encounter, there is no feasible way of preserving key program budget priorities within the framework of a $15 million reduction.

SPACE COMMUNICATIONS POLICY ISSUES

Question T-8:

At its inception, the TDRSS project was thought of as exemplifying the process of space commercialization by consolidating essential space communications and data processing activities into a single utility owned and operated by the private sector. With space commercialization receiving the increased attention of Congress, NASA, and the private sector, much can be learned from the TDRS program that can facilitate future commercialization efforts.

a. Consistent with the intent of various pieces of legislation to commercialize space, have any companies expressed an interest in providing upper stage launches for TDRSS satellites and if so, how is NASA handling these inquiries?

b. Will any part of the TDRS system be made available for commercial transmissions at some future date?

c. Will the TDRS system be made available to private ELV companies sending up commercial payloads for purposes of pre-launch and tracking support? If so, have procedures been established to support this capability?

d. It does not appear that FFB or Spacecom has shouldered any financial risk during the course of the TDRSS project. If this is the case, how should future commercial activities be approached so that private capital is subject to some level of risk consistent with the investment's potential return?

e. What is the possibility of a private company fully operating the tracking and data system -- i.e., much smaller NASA role?

f. The FY 1986 request includes funds to design an integration scheme between TDRSS and an upper stage that is non-IUS. How much money will be spent on this activity, and what are the technical problems involved?

Answer T-8:

a. Five companies have expressed an interest in providing the upper stage for the fifth and sixth TDRS launches. Selection of the stage contractor is to be accomplished under competitive procurement procedures which will afford all offerors an opportunity to compete fairly for the procurement. The request for proposals will be released in the near future.

b/c. As mentioned before, we have a policy in place to govern the use and reimbursement of TDRSS by commercial entities. The policy has been published in the Federal Register (Code of Federal Regulations) and is available to any interested party.

d. As originally conceived, TDRSS was to be funded with private capital. However, private sources were unwilling to provide that capital, and the FFB became the most viable alternative.

e. Most of the activities of the tracking and data systems programs are already carried out by private companies. Our facilities are almost exclusively staffed, operated, and maintained with contractor personnel. The role of NASA in our current activities is largely one of management, technical oversight of engineering and development, and coordination with the user community, who are largely NASA flight programs managed by other offices. We have a very small staff of civil servants involved in our activities.

f. Our budget estimate runout for this activity is $25 million. The technical problems are primarily loads definition, interface documentation, mechanical and electrical integration of the two vehicles.

Mr. NELSON. Thank you, Mr. Aller.

Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

You mentioned at the end of your statement that with the launching of the next two TDRSS missions that you will achieve full operational capability. That is despite the fact that the TDRS-A does have some reduced capability?

Mr. ALLER. Yes, sir, what our plans are there, Mr. Walker, are to launch the next spacecraft and put it in the east location, launch the third spacecraft and put it in the west location—sorry, put the second spacecraft in the west location, before one in the east; put the third one in the east location and move the spacecraft that is presently there into the in-orbit spare position. That will give us a full operational capability in the east and west and backup capability as a spare.

I should comment on your opening statement, sir.

You mentioned the 70 percent operating capability of the spacecraft. We have indeed failed 3 of the 4 KU-band forward link services we have on the first spacecraft. You recall we failed the Diplexer and the TWT. However, we can provide full services from that spacecraft with that remaining KU-band system.

So as of right now, that spacecraft can provide full support if required. We do not have a user at this time that requires that KU-band forward link.

Mr. WALKER. That is very helpful.

So, therefore it would make no sense at this point either economically or technically to talk about recovering TDRSS and doing repairs on it?

Mr. **Aller**. No, sir, it's not technically practical at this point in time. We have no capability to retrieve or to operate on vehicles in geosynchronous orbit.

Mr. **Walker**. You mentioned the Solar Max recovery and repair in your statement. How is it operating?

Mr. **Aller**. As far as I am aware, it's operating normally at this point in time.

Mr. **Walker**. Thank you, Mr. Chairman.

Mr. **Nelson**. Mr. Slaughter.

Mr. **Slaughter**. No questions, Mr. Chairman.

Mr. **Nelson**. I have a couple of questions.

Sorry, I didn't see Mrs. Meyers.

Mrs. Meyers.

Mrs. **Meyers**. No questions.

Mr. **Nelson**. Mr. Walker just to interject, I have a couple things here.

First of all, I would like you to state for the record how the location, the successful launch and placement of the TDRSS was absolutely necessary for the spacelab experiment and then I want you to relate that to how the TDRSS network is absolutely essential to the operational functioning as we envision it of the space station.

Mr. **Aller**. Well, the requirement for the spacelab and the many spacelab missions that we are going to be conducting during the late eighties has a data rate. The data rate of those payloads is very high, and the only capability we have to retrieve in real time, we can tape on board and retrieve the tapes with the shuttle, but the recovery in real time of that data, the only capability we have is through the TDRSS.

One of the major advancements of that system was to be able to retrieve much higher data rates from orbiting satellites and that was what was needed for the first spacelab mission was a year ago in December. It had a data rate of about 50 megabits, which is a very high rate, and the Landsat has 85 megabits.

In the space station era, we are evaluating the requirements on TDRSS for what the space station represents, for instance, station two orbiting platform concept, and the baseline for the station is to operate through the TDRSS system.

Now, the three-spacecraft configuration will provide full coverage, as the station orbits the Earth, from one of our single access antennas, to a polar orbiting platform, for example.

The extent of coverage and the amount of data and the amount of data you can pass from a payload back through the system, and obviously, as we get into the space station era, we will be looking at payloads that have higher and higher data rates, more imagery is what drives up the data rates.

Mr. **Nelson**. Can you tell me why you all are getting loans from the Federal Financing Bank?

Mr. **Aller**. Well, I am happy to say we are no longer getting the loans from the Federal financing bank. The loan from the Federal Financing Bank was set up many years ago as a result of initiating the TDRSS Program and finding that private financing was not available on the market to continue with the program, and the Government was required, without the Government underwriting the loan. The Government agreed to underwrite that loan, and it was determined that the Federal Financing Bank offered the best rate.

Mr. **Nelson**. All right.

Let's examine that. Normally, NASA comes to the Congress and asks for an appropriation, and that appropriation is or is not legislated into law and signed into law by the President.

Now, what was the circumstance and in what year did that occur that NASA decided that it wanted to go off of the appropriations process, and seek a loan through an outside mechanism, which is quasi-governmental? What is the history?

Mr. **Aller**. Let me touch on the history. Back in 1975, when that decision was made, the situation was that it was felt by NASA management that the technology associated with the TDRSS concept was well in hand, and that we could proceed on a commercially owned basis, commercially-developed, fixed-price basis, and that we would not buy the system, but we would buy services, which is still the case, and that the original concept was the contractor would go out on the market, borrow the money, and proceed with the program.

As I said before, it was determined that private financing was not available for that R&D nature of that kind of a system. At that time it was determined, in conjunction with the Congress, that the Government would underwrite that loan, and we would proceed on the basis of a Federal Financing Bank loan.

Now, I believe there was special legislation that permitted that at that time. I think the other circumstance that related to that was that we were in the middle of the Shuttle Program.

It was felt that the capability that TDRSS represented was a capability that was needed, and this permitted the agency to proceed with that capability without a major impact on its budget during those years.

Mr. **Nelson**. And I think you stated, and this ought to be a lesson to us far beyond the boundaries of NASA, it ought to be a lesson to us in the entire Federal sphere, that the Federal Financing Bank has been used as a mechanism to get appropriations, but not to have them show in the budget, and yet, somebody ultimately has to pay the bill, and here is a good example.

Now, I am not at all jumping on you, because I don't even know, I may not have been in this program back at the time in 1975, as you said, when this was going on, but here is a good part, and since I know a little bit about this, I think it is incumbent upon me—NASA is not a flagrant violator, but there are other agencies of Government that indeed have utilized this as a mechanism to diminish their appropriations when, in fact, ultimately you have to pay the bill, and here is a good example, because you are having to pay a $30 million prepayment on the outstanding Federal Financing Bank loans.

And that brings up another question: Why are you paying a prepayment, and when did you pay the payment?

Mr. **Aller**. The payment is due the 1st of October of every year, starting in 1986, when we have all three of our loans accumulated.

The prepayment, Mr. Nelson, results from the cap that we have on the program set by the Appropriations Committee. About a year ago at this time, we went to those committees and requested—they had capped us the previous year, and we suggested a cap of about $2.850 billion.

Mr. NELSON. What does that mean?

Mr. ALLER. $2.850 billion, the 10-year runout.

Mr. NELSON. Including interest costs as well?

Mr. ALLER. Yes, sir; we requested that cap, and they determined the cap would be established at $2.8 billion.

The program——

Mr. NELSON. The cap, $2.8 billion?

Mr. ALLER. Yes, sir; billion, in legislation. To maintain that limit, that runout over the 10-year period, we discussed with them the way to remain within that cap was to make early payments on the interest, and reduce the payments in the outyears.

Mr. NELSON. Right.

Mr. ALLER. The committees wrote a letter to OMB suggesting that be done, and as a result, we have $30 million in our 1986 request, and another $30 million in the 1987 request, to maintain a runout of about $27.90 at this point.

Mr. NELSON. That is a total of $2.8 billion which includes the interest cost of a payback of the loan over a 10-year period to build how many active TDRSS, and how many spares?

Mr. ALLER. The program consists of six spacecraft.

Mr. NELSON. Four operational and two spares?

Mr. ALLER. It includes three operational and three additional spares.

Mr. NELSON. That is conceived to be utilized over a 10-year period as well?

Mr. ALLER. Yes, over a 10-year period.

Mr. NELSON. Since the time you launched the first TDRSS, a year ago?

Mr. ALLER. Two years ago, 1983.

Mr. NELSON. Three active and three spares for 10 years of use is costing us $2.8 billion, total bill to the Government?

Mr. ALLER. Yes, sir.

Mr. NELSON. How much of that is interest cost, and how much is principal?

Mr. ALLER. About a billion is interest.

Mr. NELSON. Did everybody know this when they set it up in 1977? Did the Congress know that? Did they know the dollar figures in 1975?

Mr. ALLER. The dollar figures have increased significantly since 1975, but the commitment was made, yes, sir, and it has been reviewed every year, to my knowledge.

Mr. NELSON. The dollar figures increased as a result of what, the new technology, or the financing cost?

Mr. ALLER. No, I believe both. In the late seventies, there was a severe interest rate change. We started out, as I recall, at about a 7-percent interest, reached as high as 15- or 16-percent interest. That was one factor.

The major factor with this kind of a program, a high-technology, sophisticated program, and I mentioned this in my testimony last year, that we were developing the TDRS Program, the Air Force was developing the IUS Program, and we were also developing the

Shuttle Program and the TDRS Program, depends on IUS and the shuttle.

The major cost increases have not been changed to the cost of the concept of the program, as much as they have been interest rate and delays as a result of shuttle and IUS.

Mr. NELSON. Do you know of any other NASA programs that are funded through the FFB?

Mr. ALLER. No, sir; I do not.

Mr. NELSON. If you could carry that message back to the Office of the Administrator and if there are or presently have been within the last 10 years, I would like to know what they were.

Mr. ALLER. I will state for the record, and if it is incorrect, I will correct it, as far as I know, this is the only program that NASA has financed through the FFB.

Mr. NELSON. All right.

Mrs. Meyers, any other questions?

Mrs. MEYERS of Kansas. No.

Mr. NELSON. I know you are not feeling well, and I don't mean to be holding you, but I think that was very important that we underscore that, and again, I am not reflecting on your specific administration.

It is something that needs to be brought out. NASA seems to be the least user of the FFB. The whole Government is rife with it, and in some cases, justified, but in other cases, I wonder.

I want to ask you about achieving budgeted savings of $34 million through the closure of NASA ground stations in fiscal year 1986. It is dependent on the TDRS becoming fully operational.

All right, if there is slippage in the TDRS schedule, then how are the continued operations of the ground stations to be funded?

Mr. ALLER. Last summer, when we formulated the budget, our schedule reflected a launch in February and one in July of this year. We have had through the past several years experience with a less than solid schedule for these launches.

Our budget, therefore, was structured to allow for a launch as late as September this year or at the end of the fiscal year and to phase out the stations then early in 1986.

That manifesting schedule has undergone some changes since then, and our present schedule could be as late as November of this coming year, of this year, the first part of 1986, in which case we would extend the ground stations some period of time to insure that we had a safe operating system in the TDRS program.

We recognized that, and when I put the operating plan together for 1985, I allowed enough flexibility to provide for operation of the stations for a few months into the 1986 period.

I believe if the schedule goes beyond November of this year, we will have to seek some additional funding to maintain those stations.

Mr. NELSON. That is assuming that the third TDRS is put up in November?

Mr. ALLER. Yes, sir.

Mr. NELSON. You are covered in your budget request to us, unless that third one slips past November?

Mr. ALLER. With the 1986 budget, it is requested, and with the flexibility I have provided myself in 1985, I can cover the ground station operation through about January of next year.

Mr. NELSON. OK.

One further question, and I know you need to go, because you are not feeling well. We have had a long lead time in designing and building the TDRS. When are you and your office going to budget for a follow-on satellite to the TDRS system?

Mr. ALLER. We are evaluating that problem. We have made a commitment to a so-called space network, a TDRS program, with the phase-down of a very old, getting older every day, ground system, so we are committed to satellites, tracking stations in orbit effectively is what the TDRSS is.

With the given number of spacecraft, those spacecraft will wear out and need replacing. We are evaluating various Monte Carlo techniques, techniques used around the Government, to predict that lifetime cycle we are in with the system.

We presently feel that the system will operate well into the space station era. Around the time of the space station era, we think we are going to have to supplement TDRSS with more, basically more spacecraft of the same lot number, the same basic design as what we have.

Single antennas are the service that we need for that program, will have to be started to provide those additional spacecraft sometime in the late eighties.

Mr. NELSON. The $2.8 billion total is not going to buy anything more than the six, and we will use the six up, you say, sooner than the 10-year period that you originally planned for?

Mr. ALLER. We will have launched the six most likely in a week—I cannot tell you, there is a low probability that we could get three, four up there, and they would last for 6, 7, 8 years.

Based on probability predictions, we would look at launching five or six in the early nineties, but the lead time necessary to have vehicles on the ground ready to replace those in orbit require that the program be initiated in the late eighties.

Mr. NELSON. They would be replaced by the same thing?

Mr. ALLER. That is what we are evaluating.

Mr. NELSON. Is there any way so that we can service them and extend their life?

Mr. ALLER. No, sir, until we can develop a manned capability, we don't have that kind of retrievable repair capability, no operational capability.

Mr. NELSON. Like an orbital maneuverable vehicle, could you resupply them with that type of thing?

Mr. ALLER. If we had a vehicle that could reach geosynchronous orbit, be controlled by a TV link of some kind, we could manipulate the spacecraft; but the spacecraft have not been built for retrieval and repair, and our experience is that is a major factor.

Mr. NELSON. OK.

Any questions from anybody else?

All right, I just want to mention that we are expecting some written answers to questions that were previously submitted to you, and I suggest that you go home and get in bed and get to feeling better.

The subcommittee will reconvene tomorrow at 2, when we will have a hearing from the Office of Space Flight's Aerospace Safety Advisory Panel.

The committee is adjourned.

[Whereupon, at 4:15 p.m., the subcommittee recessed, to reconvene at 2 p.m., Wednesday, February 20, 1985.]

1986 NASA AUTHORIZATION

WEDNESDAY, FEBRUARY 20, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:05 p.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. Nelson. The subcommittee will come to order. Today we want to continue our 1986 authorization hearings by focusing on NASA's budget request for space transportation programs, including shuttles, ELV's and upper stages.

The first witness will be Jesse Moore, Associate Administrator for NASA's Office of Space Flight.

He'll be followed by Herbert Grier, who is a member of the Aerospace Safety Advisory Panel. Mr. Grier will present a statement prepared by John Brizendine, the Advisory Panel's chairman.

We're delighted with the excellent continuing progress that NASA has made in the past year in operating the space shuttle. During 1984 NASA successfully completed five shuttle missions, orbiting seven communications in two research satellites, operating the large format camera and the shuttle imaging radar, and completing numerous in-flight experiments. Particularly notable among NASA's accomplishments during the year were the spectacular on-orbit repair of the Solar Max and the retrieval and return to Earth, and the reuse, ultimately, of the two disabled communication satellites, Westar and Palapa.

These achievements demonstrated a phenomenal capability in the flexibility of the shuttle. They also demonstrated the importance of man through successful space operations and that's something that we ought to continually remind ourselves as we are analyzing where we want to go with regard to the space station. Without that on-the-spot ingenuity, adaptability and flexibility of highly trained astronauts and parenthetically, Joe Allen was just beside himself at being, one, able to fly, but two, to pull off all of those Herculean kind of feats. While without all of that these phenomenal successes would not have been possible.

We're also impressed by the progress that's being made in using the shuttle to explore the frontiers of materials-processing technology in space. The research that's underway by NASA scientists, 3M Corp., and the team of McDonald Douglas and the Ortho Corp. offer the potential of providing cures for major human diseases and disorders. It also offers new materials that cannot be manufactured here in a one-gravity environment on Earth, and also offers a major new era of economic growth for the future of the United States.

So, I'd like to thank our first witness, Mr. Moore, for once again being here to testify on this important part of NASA's activities. Now, at this point I would turn to my colleague and ask for his comments, Mr. Walker, and he is on his way and we will certainly have unanimous consent, without objection, that he will be able—permitted to insert his comments in the record and if he so chooses to make it verbally once he arrives.

[The prepared opening statement of Mr. Walker follows:]

OPENING STATEMENT FOR
HONORABLE ROBERT S. WALKER
NASA AUTHORIZATION HEARING
SPACE, SCIENCE AND APPLICATION SUBCOMMITTEE
FEBRUARY 20, 1985

GOOD AFTERNOON, MR. CHAIRMAN. I JOIN YOU IN WELCOMING OUR WITNESS HERE TODAY. AS A MEASURE OF THE INTEREST OF MEMBERS FROM THIS SIDE OF THE AISLE, I WOULD LIKE TO POINT OUT THAT YESTERDAY WE HAD ALMOST EVERY REPUBLICAN MEMBER OF THE SUBCOMMITTEE IN ATTENDANCE. I APPLAUD THAT PARTICIPATION, AS I KNOW THE CHAIRMAN DOES.

TODAY WE LOOK AT NASA'S PLANS AND POLICIES CONCERNING THE SPACE SHUTTLE PROGRAM AND EXPENDABLE LAUNCH VEHICLES.

THERE ARE A NUMBER OF MAJOR QUESTIONS THIS COMMITTEE MUST ADDRESS THIS YEAR. AT THIS POINT WE ARE PROBABLY FAR FROM CONSENSUS. MUCH OF THE INFORMATION WE NEED TO REACH POLICY DECISIONS WILL COME FROM WITNESSES TODAY AND OVER THE NEXT FEW WEEKS.

AMONG THE QUESTIONS WE NEED TO FIND ANSWERS TO ARE:

*WILL A FIFTH SPACE SHUTTLE ORBITER BECOME NECESSARY? WHILE IT APPEARS THAT THIS DECISION DOES NOT HAVE TO BE MADE THIS YEAR, HOW MUCH LONGER CAN WE PUT IT OFF, AND WHAT ARE THE COSTS INVOLVED?

*WHAT ARE THE DOD REQUIREMENTS FOR ELVS IN EXCESS OF ORBITER REQUIREMENTS? WE UNDERSTAND THAT THE AIR FORCE INTENDS TO PROCURE 10 ELVS AT A COST OF APPROXIMATELY $2 BILLION AND LAUNCH THEM AT A RATE OF 2 PER YEAR FROM 1988 THROUGH 1992.

*WHY DOES THIS REQUIREMENT EXIST IF AIR FORCE REQUIREMENTS DROVE SPACE SHUTTLE DESIGN?

*IF DOD STARTS TO CONTRACT ELV LAUNCH SERVICES TO OTHER GOVERNMENT AGENCIES, SUCH AS NOAA, WHAT WILL THE IMPACT BE ON SHUTTLE OPERATIONS?

I HAVE A DEEP AND CONTINUING CONCERN THAT THE MORE SUCCESSFUL THE SHUTTLE PROGRAM BECOMES, THE GREATER THE POTENTIAL DANGER IS THAT SHUTTLE OPERATIONS COSTS WILL DRIVE THE OVERALL NASA BUDGET IN YEARS TO COME.

THERE HAVE BEEN A NUMBER OF PROPOSALS WHICH WOULD FENCE SHUTTLE OPERATIONS WITHIN NASA OR TRANSFER THEM TO SOME OTHER GOVERNMENTAL, OR QUASI-GOVERNMENTAL AGENCY, OR TO SOME PRIVATE ENTITY.

IT SEEMS THAT ONE OF THESE ALTERNATIVES MAY BECOME NECESSARY SINCE IT APPEARS THAT WE WILL ONLY BE ABLE TO GET LIMITED FINANCIAL RESOURCES IN THE YEARS TO COME.

MR. CHAIRMAN, I LOOK FORWARD TO HEARING THE TESTIMONY.

Mr. NELSON. So, let's start with Mr. Moore.

STATEMENT OF JESSE W. MOORE, ASSOCIATE ADMINISTRATOR FOR THE OFFICE OF SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY MIKE WEEKS, DEPUTY ASSOCIATE ADMINISTRATOR (TECHNICAL), AND MACK STEEL, DIRECTOR OF RESOURCES

Mr. MOORE. Thank you, Mr. Chairman. With your permission I wish to submit my written statement for the record and present a short oral statement, followed by several charts, which will describe and highlight the activities and plans in the Office of Space Flight.

Mr. NELSON. All right. Are you prepared—are you following a prepared text on your short oral statement?

Mr. MOORE. Yes, I am.

Mr. NELSON. May I have a copy of that?

Mr. MOORE. Yes, you may have a copy of that.

Mr. NELSON. All right. This is it dated February 20?

Mr. MOORE. That is correct, sir.

Mr. NELSON. Fine.

Mr. MOORE. I want to first offer my congratulations to you as being named chairman of this distinguished subcommittee.

Mr. NELSON. I'm just like a kid in a candy store.

Mr. MOORE. And we look forward to working with you in your new capacity.

Mr. Chairman, and distinguished members of the committee, I am pleased to appear and present the NASA budget request for fiscal year 1986, for the Office of Space Flight. The programs in the Office of space flight include the space shuttle, spacelab, expendable launch vehicles, various upper stages, and advanced programs.

Mr. Chairman, during the past year space shuttle has continued to prove itself an extremely versatile and reliable space transportation system. With the Solar Max repair, Palapa and Westar retrievals, and for orbital refueling demonstration, we have witnessed another major step in the evolution of space.

As the primary space launch system for both national security and civil Government missions, the President has directed that NASA's first priority is to make the space transportation system fully operational and cost-effective in providing routine access to space. Our program plans and budget requests for fiscal year 1986 fully support this priority.

We are pleased that our fiscal year 1986 budget request includes $25 million for initiation of the orbital maneuvering vehicle development. The OMV, which is a reusable remotely piloted system, represents, I believe, a significant extension of capability for the STS, as well as a very valuable space infrastructure element for the space station. With a fiscal year 1986 start we will be able to operate the OMV initially in 1990.

Now, I'd like to review with you briefly the charts which highlight our program accomplishments and describe some of the plans, activities that we have laid out in the program.

Let me have the next chart, please. I think you covered most of the highlights of the mission here, Mr. Chairman, I'll quickly go through the ones that we launched since the last time we talked to this committee. Our launch in February, as you know, was highlighted by a number of accomplishments, deploying a couple of communication satellites, as well as the first flight of the manned-maneuvering vehicle and also, very important to the program, was our first landing at the Kennedy Space Center. As you know we've had two additional landings at the Kennedy Space Center and our plan is to continue landing our programmed flights at the Kennedy Space Center, when at all possible.

The next flight was a very significant flight, next chart please, and that is we repaired the Solar Maximum spacecraft. This was accomplished in an efficient time line, shorter than planned, the satellite is operating very, very well at this point in time, and I believe it has clearly demonstrated the value of man and machine in orbit.

We also deployed the LDEF satellite during that last flight in April and our plans are to retrieve LDEF approximately a year later, this coming March.

In August, after recombining a couple of flights, we had a number of accomplishments in the August flight. We deployed three communication satellites. We flew the payload specialist from McDonnell Douglas, Charlie Walker, to operate his continuous flow electrophoresis system, we also demonstrated the Frisbee deployment of the Syncom satellite, which is a shuttle-optimized satellite, this worked very well and has worked subsequently well on the additional deployment we've had, and we also did a number of tests on the OAST-1 solar array experiment, which proved very useful in terms of understanding the dynamics of deploying large structures in space.

In our October flight we flew a seven-member crew, we had two women on board, and we also flew our Canadian Astronaut, Mark Garneau, on that particular flight. We also accomplished the first EVA by a woman astronaut from the U.S. program, Kathy Sullivan, and she very effectively demonstrated our orbital refueling capability, which I think will be valuable to us downstream in the evolution of the shuttle program.

In addition we deployed a very important scientific satellite, called the ERBS satellite, and here, if you recall, the shuttle, I think, performed a very, very useful role in actually holding on to the ERBS satellite until the solar arrays were fully deployed during that particular mission.

Next please.

In 51-A, was certainly one of the highlights of last year's program, and that was when we used the shuttle to go and retrieve the Westar and Palapa satellites. As you recall these were launched back in February of 1984 and in some 9 month's time we were able to successfully go up, rendezvous, capture and bring back to earth these two important satellites.

We also flew, for the first time, a 3M experiment, which has performed exceedingly well and has yielded very, very good results in terms of materials processing in space.

Next please.

This is the recent, most recent flight we completed, which is a DOD flight in January. And, it was a very successful flight and we'll look forward to continuing additional good flights with the Department of Defense.

Now, in terms of the plans for the remainder of fiscal year 1985, we plan to recover the LDEF [long duration exposure facility] during our March flight, return it back to Earth after about a year in orbit, to understand the effect of space and zero gravity on these experiments after a year. We have two dedicated spacelab flights that are planned in this period of time. The one flight coming up in the April timeframe is another flight of a long module configuration on spacelab. Then we have the first flight of the igloo, plus pallet configuration with the instrument pointing system that was delivered by ESA, coming up in the July timeframe. These will be two very important flights for the spacelab program.

We also have planned the two tracking and data relay satellites, one TDRS satellite is scheduled for launch early March and the other satellite is in the process of being—we're looking at the precise launch date for the second TDRS and it may, in fact, occur in fiscal year 1985, in the September timeframe or it may move into the October or November timeframe. We're still debating that and working it with some of our customers to see what we can derive—what launch vehicle we can derive for the second TDRS satellite.

We also are looking forward to the first flight of Spartan, which is a science payload that will be remotely deployed from the shuttle and conduct space science and it will be retrieved by the shuttle during each of the missions. And I think we'll see a long run of Spartan flights in the future for acquiring valuable space-science data.

We have eight communication satellites on the manifest. We plan to refly the continuous flow electrophoresis experiment, along with the McDonnell Douglas payload specialist, Charlie Walker, that's coming up in the March timeframe. And we also—important, very important to the program, are planning to deliver orbiter Atlantis in the April timeframe and put this into our stable of orbiters and it will help us increase the overall flexibility of our program. So, we're looking forward to the delivery of Atlantis and its first flight. Overall, in fiscal year 1985 we plan a total of 10 shuttle missions.

In fiscal year 1986 there are also a number of activities that are planned and these kind of highlight the activities. A number of significant events are coming on line during that year and I believe, also, in 1986 will be a banner year for space science. Highlights of our program in 1986 include the launch of 11 commercial satellites. We will launch and operate the first commercial dedicated spacelab flight. This is actually a reimbursable spacelab, it's the German D-1 flight, which is scheduled for launch in the fall of 1985.

We also plan to initiate our launches from Vandenberg, with the Air Force. Our first launch is planned from there no earlier than January 29, 1986, and also around the first of January 1986, another valuable asset will come on line to the program, and that's the second launch pad from the Kennedy Space Center.

I mentioned to you the importance of space science in 1986 and the role the shuttle will be playing. There are four launches that I think are extremely important to the Space Science Program and we're glad to participate in launching these vehicles. The first is the ASTRO-1 Launch in March of 1986, which will provide observations of comet Halley as it approaches the Earth, will carry three ultraviolet telescopes for making scientific observations.

We also have scheduled in May of 1986 two planetary launches. These will be launches of the Galileo spacecraft to Jupiter, as well as the Ulysses spacecraft to Jupiter and then around the Sun. These will be two launches in a very short period of time, using both pads at the Cape, two orbiters, as well as it will be the initial flights of the upper stage Centaur, which we've had under development for some time.

Equally important will be the launch in the summer of 1986 of the Hubble Space Telescope. I think you've heard the attributes of the space telescope and we're all looking forward to seeing this get into orbit and yield some of the scientific data that we have—we will be expecting to see. We also plan to continue to fly the EOS [Electrophoresis Operations in Space], which is a cargo-bay version of the CFES experiment and we expect to continue flying the 3M material sciences experiments during this period of time.

Also during fiscal year 1986 will be our initial flight of the space flight participant. This is the teacher in space and that flight that we are looking at right now is in the latter part of 1985, the November timeframe, to fly the teacher in space. As you know we have a selection process underway now to select that participant. Total, we will fly 14 shuttle missions in fiscal year 1986, is our plan.

This is a picture, Mr. Chairman, of the Centaur G-Prime test vehicle. It is undergoing tests at this point in time. We are on a schedule to deliver to the Cape in July of 1985, the first vehicle and about 3 months later the second vehicle for these two planetary vehicles. The G-vehicle, which is a shorter version for the Air Force has completed major design reviews and we've started fabrication on it. We have, however, been advised recently that our estimates for completing the development and the procurement of the first four Centaurs has grown a little bit. We have sent some teams to Lewis and out to General Dynamics to review the current cost situation relative to the Centaur Program. Do not have the final answers at this point in time, however, we do think within the flexibility of our program we will be able to solve the Centaur problem, and we'll keep this committee informed as we get more information on the Centaur status.

We believe we are on schedule to meet the planetary launches in 1985—in 1986 and we do think we can resolve the cost situation within our own program for fiscal year 1985 and 1986, and we are working at that now.

This simply shows a picture of the Galileo spacecraft, I've talked about it and you should note the very narrow launch window, which opens on the 19th of May and closes on the 6th—on the 9th of June. This will be a very, very important mission in terms of understanding the Jovian System and it will be an important flight for us in terms of launching the Centaur vehicle.

The next flight is the Ulysses spacecraft. This is the—formally known as the International Solar Polar Missions, the European spacecraft that will fly to Jupiter, use the gravity assist of Jupiter to essentially reach a high heliocentric latitude around the Sun, greater than 60 degrees above the Sun. Launch window for that is from the 15th of May through the 9th of June as well. Both are to be launched during that short period of time.

Needed for that launch is Pad-B. I'm pleased to report it is coming along well. Construction is ahead of schedule and we feel very confident that Pad-B will be on line by January 1, 1986, and will become, as I said, a very important asset to our program in terms of meeting out launch rate predictions.

The Vandenberg status, I'm pleased to say that Vandenberg is making progress. We recently had a tour of Vandenberg, back in the December timeframe, with Under Secretary Aldridge, went out and looked at the Vandenberg, I think a lot of progress is being made at Vandenberg. As you know, we deferred the initial launch from Vandenberg from the middle of October 1985 until no earlier than January 29, 1986, in order to permit us to: Hang on to Discovery for another couple of flights. We had originally intended to ship Discovery to Vandenberg in the May timeframe and we've now held onto Discovery until the September timeframe, and in addition to that there were some payload problems reported, so we mutually felt it was in the best interest of the program to defer until no earlier than 1986. I think we'll meet this and it in on schedule, as I said, for the first payload launch out of Vandenberg.

Needed for that is the filament wound case. As you know the filament wound case provides us about 4,600 pounds of payload improvement. That's very important to achieve the west coast payload goals. I'm pleased to say that we are on schedule to support the first Vandenberg-1 launch. Two segments have been filled with propellent now and they are scheduled for delivery to Vandenberg in May.

We have successfully test fired the development motor 6 flight in October, that went very well. Our next full-scale testing of the filament wound case is scheduled in April and we plan to complete all deliveries to Vandenberg in June. Technical problems that we've had we believe we understand, the delamination problem, as well as some of the deflection problems. We've made measurements on these and we've got inspection techniques, nondestructive sensing techniques that we feel pretty good about where we are in the filament wound case application for Vandenberg.

I should also say that all segments are wound. Hercules has completed the winding of all segments and we are now in the process of getting them to Thiokol ready for shipment out to Vandenberg.

This is our planned flight rate from fiscal year 1985 through 1988. I mentioned to you earlier, we plan 10 flights in 1985, 14 in 1986, building up to 19 in 1988 and then beyond that our projection is 24 flights per year. We will have all four orbiters in the stable by the end of this fiscal year. Atlantis is scheduled for its flight in the September timeframe of 1985.

I mentioned to you, at the outset, the importance of OMV to the program. This capability will provide delivery, retrieval and boost capability. It will extend the capability of a shuttle by about 1,500 nautical miles. In addition, it will provide us about ±8° of plane change capability in order to boost payloads up to higher altitudes, in order to retrieve payloads back to the shuttle. We are currently in what we call phase B. We have phase B contracts with LTV, Martin Marietta and TRW and we plan to initiate full-scale development phase of this in January of 1986. And, our first launch of this is in 1990. We think this is timely from the standpoint of providing us the capability to potentially boost space telescope, other observatories during this period of time, as well as to gain significant operational experience prior to the space station era, so we're very pleased that the OMV is included in our program for fiscal 1986.

This final chart is our budget summary. Our request in space flight, control and data communications is $2.701 billion and in space transportation capability development it is $459 million. As you can see from the chart, our shuttle production and operations capability is coming down and our operations is increasing. And, this is what's to be expected as we complete the R&D phase of the program and enter the operational phase. We expect our funding to go down in production and increase in operations. What is not included on here, by the way, are reimbursements that we receive in the program in 1986.

The Capability Development Program includes our spacelab program, where we're transitioning from development to operations. We have completed, essentially, the second spacelab unit and we're in the process of working with ESA for the delivery of the second flight unit of the instrument pointing system.

The upper stages basically covers support to the PAMS, the IUS's and new missions, such as the TDRS F has been added and we have priced upper stages for that in this catagory. The ETB [engineering and technical base] basically provides institutional support at our centers, at the OSF centers. Our manpower is constant and throughout this period of time here between 1985 and 1986. Our payload operations and support line item basically covers the integration of NASA payloads, such as the Galileo, Ulysses, radar mapper, space telescope, as well as spacelab's payload operations center. Advanced programs include such things as the orbiter transfer vehicle, R&D part, advanced transportation studies, tether applications, etc. The Tethered Satellite System is a flight project that was initiated last year and it is in the process now. We're working with the Italians. It's a cooperative program with the Italians scheduled for flight in late 1988 or early 1989. And then I mentioned the orbiter maneuvering vehicle, where our first requirement for funding, development funding in fiscal 1986 is $25 million.

Charts off, please.

In summary, I'd like to say that we are determined to continue to help this Nation provide leadership in space transportation. The STS team will continue to vigorously pursue improvements in the efficiency, reliability and flexibility of the system. We look forward to a challenging and rewarding future as we fully exploit the versatile capabilities of the shuttle.

With your help, we can meet the challenges of the future.

Thank you very much, Mr. Chairman and members.

I should point out that with me at the table, from the Office of Space Flight, on my left is Mr. Mike Weeks, who's Deputy Associate Administrator for Technical, in the Office of Space Flight, and Mr. Mack Steel, on my right, who is the Director of Resources.

Mr. Chairman, we would be pleased to answer questions at this time.

[The prepared statement plus charts shown during Mr. Moore's oral presentation, and also additional questions to answers follow:]

Statement of

Jesse W. Moore
Associate Administrator
Office of Space Flight

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

It is a pleasure for me to make my initial appearance before this Committee as Associate Administrator for Space Flight. I am pleased to present the NASA budget request for FY 1986 for the Office of Space Flight.

The President has directed that NASA's first priority is to make the Space Transportation System fully operational and cost effective in providing routine access to space. He has also directed that the STS Program will receive sustained commitments by all affected departments and agencies and directed that enhancements of STS operational capability, upper stages, and efficient methods of deploying and retrieving payloads will be pursued as national requirements are defined.

The Space Shuttle continues to prove itself an extremely versatile and reliable space transportation system. Since last year's testimony, the operational capability and potential of the Shuttle have been demonstrated repeatedly.

With the repair of the Solar Max Satellite, the retrieval of the Westar and Palapa communications satellites, and the orbital refueling demonstration, we have witnessed another step in the evolution of space. We can extend the useful life of our spacecraft, correct unforeseen spacecraft problems, and reduce the risk inherent in space ventures with the unique capabilities of repair, refueling, and retrieval provided by the Space Shuttle.

As the primary space launch system for both national security and civil government missions, and, with the advent of the Space Station, it will be even more incumbent on the agency that we make it fully operational and provide routine transportation to low-Earth orbit, and that we have the ability to place spacecraft in geosynchronous orbit on a routine basis at the lowest possible cost, as well as provide the opportunity for scientific exploration and the advancement of technology that can make all our lives on Earth better.

Our FY 1986 budget request for the Space Transportation System Program is $3.1609 billion. This includes $2.7016 billion for Space Flight, Control, and Data Communications and $459.3 million for Research and Development.

During 1986, we will launch two of our most exciting scientific missions -- Galileo and Ulysses, eleven commercial communications satellites, a commercial dedicated Spacelab flight, the Hubble Space Telescope, the Astro Pallet for Halley's Comet observations, and the first launch for the Vandenberg launch site. The Ulysses mission, previously called the International Solar Polar Mission (ISPM), will be the first mission to investigate the sun from a polar perspective. The mission, scheduled for May of 1986, will use Jupiter's gravitational effect to place the satellite in solar polar orbit. Six days later, the Galileo mission is scheduled to be launched. Its mission is to orbit planet Jupiter to study the Jovian atmosphere and moons, including deployment of an atmospheric probe.

Before turning to the details of the budget request, I would like to review a few of our major accomplishments during 1984, our plans for 1985, and report on our programs for which funds are requested in FY 1986.

STS Mission Highlights

Space Shuttle missions in FY 1984 achieved numerous milestones both commercially and in science and technology. In FY 1984 we deployed five new commercial communications satellites for Western Union, Indonesia, Satellite Business Systems, AT&T, and Hughes Communications.

Two communications satellites for Western Union and Indonesia were successfully launched and deployed from the Shuttle but failed to achieve their proper operational orbits due to upper stage failures. The satellites were spectacularly retrieved in our November mission and brought back to Earth for refurbishment. NASA and the space insurance industry cooperated closely in this first effort. The two satellites are currently being refurbished, and we understand that the space insurance industry is in the process of reaching an agreement on their resale.

Another of the Shuttle's spectacular missions this year was the repair of the SMM during mission 41-C. On April 6, 1984, the Shuttle rendezvoused with and berthed a partially operational spacecraft, the Solar Max (SMM). The Solar Max spacecraft had been launched in 1980 but was disabled by the failure of its fine-pointing system. The Solar Max Repair Mission used extravehicular activity (EVA) techniques to repair and restore to service the malfunctioning spacecraft. This enabled the Solar Max to resume its program of solar observations and measurements in the visible, ultraviolet, and x-ray portions of the spectrum.

The Long Duration Exposure Facility (LDEF) was also deployed on this same mission. This facility supports a large number of long duration exposure experiments. It will be retrieved later this year.

For this mission, we employed for the first time an ascent technique known as direct insertion. This technique, used for high orbital altitude requirements, uses the Shuttle's main engines to achieve the desired apogee - in this case, 250 nm. Because only one Orbital Maneuvering Subsystem (OMS) burn is required to circularize the orbit following main engine cutoff, the OMS propellant is conserved for later use in the missions. This technique eliminates the need for additional OMS tank kits for high altitude payload delivery missions.

On a direct insertion ascent, the external tank enters the atmosphere over the Pacific Ocean rather than the Indian Ocean. Using airborne and ground-based optical and radar instruments, we were able to gain valuable data on the External Tank (ET) entry, break-up, and debris "footprint" following its entry south of Hawaii.

The next mission, STS 41-D, in August 1984, provided a step towards improved electrical power systems for Space Station and future interplanetary spacecraft with the lightweight deployable solar array (OAST-1). This 13 x 102 foot array demonstrated erection from and retraction into a 7-inch deep container. Measurements were made of the dynamic response to induced vehicle motion, which verified and refined analytical techniques.

In addition to the retrieval of the Palapa and Westar satellites mentioned previously, we also had another first involving commercial communications satellites -- we successfully launched and deployed three such satellites on the STS 41-D mission.

On Shuttle flight 41-G, the capability to refuel spacecraft on orbit was demonstrated for the first time completing the initial three "R's" of the National Space Transportation System of Retrieve, Repair, and Refuel. The flight demonstration included six transfers of hydrazine fuel between a resupply tank and a simulated spacecraft propulsion tank utilizing existing flight fill ports. The Orbital Refueling Demonstration tanking system can now be configured for operational use to refuel spacecraft.

Our flights have served many engineering objectives and have provided outstanding scientific benefits as well. The resounding success of the first Spacelab mission on STS-9 is a prime example. The Spacelab program had a banner year in FY 1984. The first Spacelab mission, a system verification and science gathering mission, was an unqualified success. The joint NASA/European Space Agency mission demonstrated the versatility and broad application of Spacelab as a space research facility. The Spacelab-1 mission yielded a significant science return because of the manned operations and their direct involvement with the experimenters on the ground.

The initial operational flight of the Spacelab Pallet System successfully supported the Office of Space and Terrestrial Applications (OSTA-3) mission, wherein a significant amount of new data was collected relative to the Earth's characteristics using a radar instrument. The Spacelab pallets were also used on the satellite retrieval mission and served as the carrier for the two satellites which were returned to Earth. The Multipurpose Experiment Support Structure was used on the OAST-1 mission, an experiment involving deployment of large structures in space and the Large Format Camera.

The first of three satellites to monitor solar radiation received by, and thermal radiation from Earth for effects on weather and climate shift, the Earth Radiation Budget Satellite (ERBS), was also launched. This 5000 lb. spacecraft was lifted out of the bay, the appendages were erected, and it was checked out and deployed at 160 nm. It used its own propulsion to reach its operating orbit of 379 nm at 57 degrees inclination. Full operation has been verified, and results are coming in.

Also notable is the operation of the Shuttle Imaging Radar (SIR-B), which extended the technique used on STS-2 (SIR-A) to higher inclination for greater geographical coverage (57 degrees). The higher resolution imagery of SIR-B supports investigation in geology, cartography, oceanography, archeology, vegetation studies, etc. The study sites include East Africa, Canada, U.S., Australia, New Zealand, Germany, The Netherlands, Japan, Sweden, Peru, China, Saudi Arabia, India, Atlantic and Pacific Oceans, the North Sea, and others.

The Large Format Camera provided high resolution (70 ft), wide field of view (140 x 280 statute miles) with stereoscopic coverage.

Other investigations included wide-scale Measurement of Air Pollution from Satellites, ground Feature Identification and Location Experiment, Auroral Photography Experiment, cloud photography, and direct oceanographic observations done by an onboard Navy oceanographer.

Flight crew members made important contributions to the advancement of the STS during FY 84. During the STS 41-B mission, Mission Specialists (MS) Bruce McCandless and Robert (Bob) Stewart successfully flight tested two Manned Maneuvering Units (MMU's) by propelling them over 300 feet away from Challenger's payload bay and back.

Commander Robert (Bob) Crippen and Pilot Francis (Dick) Scobee demonstrated the Orbiter's navigation and maneuvering capabilities during the Solar Maximum Repair Mission (STS 41-C) by rendezvousing with the SMM satellite. MS Terry Hart exhibited the versatility of the Remote Manipulator System (RMS) by maneuvering the RMS arm to grapple the satellite when the MMU was unable to dock with and stabilize the spacecraft. MS George (Pinky) Nelson and James (Ox) van Hoften repaired the SMM satellite, and the RMS was used to release it back into orbit. The STS 41-C crew successfully demonstrated the capability to repair satellites in orbit.

MS Judith (J.R.) Resnik operated the 102 ft. OAST-1 solar array during the STS 41-D (Rev) mission and obtained valuable data on the performance and structural dynamics of the large, low-cost, lightweight, deployable/retractable structure. In the future, a similar solar array may be used to supplement the Orbiter's power and may be applied to the development of NASA's Space Station.

During the STS 41-G mission, MS David (Dave) Leestma and Kathryn (Kathy) Sullivan performed an EVA to install a flex-line mod kit in an Orbital Refueling System (ORS) prototype. Liquid hydrazine was safely passed through the flex-line, demonstrating the capability of refueling satellites in orbit.

Commander Frederick (Rick) Hauck and Pilot David (Dave) Walker demonstrated the navigation and maneuvering capability of Discovery during the

STS 51-A mission when they rendezvoused with the Palapa and Westar satellites. MS Joseph (Joe) Allen and Dale Gardner utilized MMU's to fly over and capture the two satellites, and then berthed the satellites in the payload bay after participating in real-time planning to modify the original berthing procedures. The STS 51-A mission highlighted the capability of the Space Shuttle program to retrieve satellites.

Payload specialists played a major scientific role in this year's flights. The first industry payload specialist, C.D. Walker from McDonnell Douglas, operated the Continuous Flow Electrophoresis System (CFES) experiment which exploits the microgravity of orbital flight to improve the separation of large organic molecules for production of new pharmaceuticals. An additional flight is planned leading to a pilot production version to operate in the payload bay.

P.D. Scully-Power, an oceanographer from the U. S. Navy, did direct interpretation of oceanographic phenomena as observed from space augmented by hand-held photography and correlated with radar and LFC imagery.

Additionally, Canadian payload specialist Marc Garneau conducted Canadian experiments (CANEX) involving automatic video analysis for ranging and tracking, composite materials exposure, sun photometry, atmospheric emission and Shuttle glow, and space adaptation studies.

Another of our exciting programs is the Space Flight Participant Program which we established this spring as a means to include private citizens on Shuttle missions. On August 27, 1984, President Reagan announced that the first space flight participant would be selected from among the Nation's elementary and secondary school teachers.

The Announcement of Opportunity outlining the eligibility requirements for teacher candidates was released on November 8, 1984, generating requests for information from 35,000 teachers in the United States, our territories, and dependent overseas schools.

The Council of Chief State School Officers has been contacted by NASA to conduct the search. A primary and back-up candidate will be announced in September of 1985. An early 1986 mission will be identified on which the teacher will fly.

Program Status and Plans

During FY 84, we have continued to take steps to make the Shuttle fully operational and cost effective.

The fourth Shuttle Orbiter, Atlantis, will join the fleet this spring and is scheduled to fly its first mission this year. Although we are well into the Shuttle's operational phase, we will continue to work to improve performance, procure spare parts, and enhance reliability.

In the production phase, the effort of delivering orbiters will have been completed in FY 1985 with the delivery of Atlantis. The modifications to Columbia, bringing it to its operational configuration, will have also been completed.

There are continuing activities in the production phase -- the completion of modifications to Atlantis and Discovery to accommodate the Centaur upper stage, performance augmentation activities to conduct orbiter loads analysis in support of the Solid Rocket Motor Filament Wound Case Development Program, and the design of flight software.

A new production activity is the upgrading of the General Purpose Computer (GPC). The new GPC provides needed ascent memory and ties us with the industry trend to standard architecture while preserving our current software investment.

The logistics activities include both structural spares and initial spares. The structural components include elements such as wings, vertical stabilizer, crew module, payload bay doors, and aft thrust structure. These elements will be assembled into varying stages of completion to be used as structural spares for the current fleet.

Logistics support includes the lay-in of Orbiter initial spares and rate spares to meet the requirements for a twenty-four per year flight rate. Maintenance test equipment is also provided as part of the interim depot and maintenance support. Final determinations on depot and maintenance support are under study.

A team consisting of USAF military and contractor personnel, supplemented by experienced Kennedy Space Center personnel, has been established at VAFB. Through their cooperative efforts, good progress continues to be made in preparing the launch site for the first launch, now scheduled for no earlier than January 29, 1986. All construction activities are proceeding with no known schedule impacts.

The facility verification vehicle (OV-101/Enterprise) was delivered last November, followed by the ET and inert Solid Rocket Booster (SRB) segments, and facility verification testing is under way. Delivery of the first flight vehicle (OV-103/Discovery) is scheduled for September 1985.

Since last year, there has been a major replanning of the Space Shuttle Main Engine (SSME) program. The restructured program consists of three parts -- (1) flight operations, (2) product improvement, and (3) advanced development. The flight operations continues virtually unchanged from last year. The near-term portion of the product improvement element also continues virtually unchanged from last year. The emphasis of the near-term product improvement is on improved high pressure pumps, a redesigned powerhead, and a more efficient production process. The out-year portion of the product improvement element, being conducted at the prime SSME contractor, was significantly reduced and the advanced development element created.

The advanced development element has two major thrusts -- alternative engine contractors and a technology test bed. Two rocket engine companies, Aerojet and Pratt & Whitney, are studying the SSME with a goal of improving the SSME life by applying alternative approaches and/or advanced technology to problem areas. In subsequent phases of this competitive effort, the alternative contractor(s) will fabricate and test hardware. The details of the technology test bed program are still evolving but will be accomplished at Marshall Space Flight Center (MSFC). One use of the technology test bed will be to test the hardware that is produced from the competitive effort.

The final FWC qualification test firing is scheduled for the fourth quarter of FY 1985. The first FWC SRM flight set will be loaded and assembled for delivery to VAFB in the third quarter of FY 1985 in support of the first flight.

Efforts will continue toward minimizing hardware damage at water impact and incorporating producibility improvements to reduce hardware turnaround time.

Twenty-four boosters (12 flight sets) will be delivered to KSC in FY 1985 to support the flight mission model.

In the ET, procurement of additional tooling will continue the buildup of our capability to support higher flight rates. Producibility and production readiness efforts will complete implementation to further enhance manufacturing process to achieve planned cost reductions. Eleven tanks are scheduled for delivery in FY 1985.

Transition of Ground Support Equipment (GSE) from the NASA Flight Element Projects to KSC is nearly complete for all but the Orbiter project. This consolidation provides for a more efficient logistics initial lay-in and sparing system at our primary launch and landing site. The Orbiter GSE transfer will be completed in 1985. Consolidation of flight hardware at KSC has been initiated and will further increase logistics sparing effectiveness in the coming years.

During the past several years, there has been concern over the logistics spare quantities available to support the Shuttle flight operations. Of special concern has been the high pressure pumps for the Space Shuttle Main Engines (SSME's) following our concentrated effort to reach our complete spare goals. I am happy to report that we have seen progress this past year. At the end of FY 84, our two operational Shuttles were completely equipped with SSME's including a full complement of high pressure pumps. In addition, there is a spare engine, including pumps, at KSC. The main propulsion system testing at full power level (109% thrust) has been on hold until sufficient high pressure pumps became available. Testing is now planned for the April/May 1985 timeframe.

To accommodate our expanding fleet and operational capabilities, the Solid Rocket Motor (SRM) Processing Facility is under construction at KSC to enable safer and more efficient processing and storage of the SRM's and aft segments.

We are now constructing a new Solid Rocket Booster (SRB) Refurbishment Facility in order to move the Marshall Space Flight Ccenter/BAC (Booster Assembly Contractor) activity from the KSC Vehicle Assembly Building (VAB) low bay to enhance safety and increase the capacity from 16 to 24 or more flight sets per year.

Other major activities will include the continuing activation of launch pad B, leading to its planned operational readiness in January 1986; activation of the third mobile launch platform, leading to operational readiness in September 1986; and launch equipment modifications to provide the capability to service the Centaur upper stage for initial Centaur flights. This is a tight, but doable, schedule to support the Galileo and Ulysses missions. Modifications to improve the capability of the Spacecraft Assembly and Encapsulation Facility (SAEF-2) have been completed. We also brought into use a second payload canister which enhances payload operations. Construction and activation by January 1986 of a cargo servicing facility is currently under way.

The modification of a third Gulfstream II for use as a Shuttle Training Aircraft (STA) will be completed, and the STA will be delivered in FY 1985. We are also evaluating the potential for obtaining a second Shuttle carrier aircraft.

This year saw the first full year of operations at KSC under the Shuttle Processing Contract (SPC) and the Base Operations Contract (BOC). Both contracts continue to show increased efficiencies. Lockheed Corporation, the SPC, was fully responsible for the successful turnaround processing of STS 41C and the three subsequent missions. Under the SPC, turnaround capability has continued to improve.

At the Johnson Space Center (JSC) we are planning a Space Transportation System Operation Contract (STSOC) to consolidate work now being performed by 16 contractors into a single contract. The selected contractor will assume increasing responsibility to perform and manage STS operations functions. The Government, however, will retain final authority for mission readiness, mission conduct, and mission safety.

The STSOC contractor will be expected to maintain high standards of safety and reliability for STS missions, introduce new and innovative management procedures to improve efficiency and productivity, reduce the total cost of STS operations, and accommodate a flight rate which is projected to increase to 24 per year.

The Request for Proposal (RFP) for the STSOC contract was released on January 14, 1985. This procurement represents significant changes in contract philosophy for the STS operations era. These changes should produce further reductions in STS operations costs while maintaining space flight quality products and services on a timely basis. This would be accomplished by: (1) consolidating like functions; (2) reducing and streamlining the multiplicity of management and technical interfaces among the different contractors and their NASA counterparts; (3) turning over more of the overall integrated management and end product responsibility to the contractor; and (4) providing the contractor with significant motivation for cost savings through the availability of an incentive fee for cost performance in combination with, and balanced by, the more traditional award fee for technical performance. An additional benefit of these changes will be the opportunity it provides NASA to selectively withdraw its personnel over time and reassign them to other priority programs.

As you are well aware, because of our commitment to achieve 24 flights per year, with 20 at KSC, we are placing strong emphasis on our ability to turn around flight hardware in an expeditious manner. Our initial experience between STS-1 and STS-2 was a turnaround of 187 working days. Continuous planning and optimization of activities, hardware, support equipment, and facilities have resulted in reducing this turnaround time on the same vehicle to 53 working days. This is projected to continue to improve in order to achieve a 35-workday turnaround in 1985.

We have begun implementing a plan to optimize major hardware production and provide flexibility in hardware production rates. A production base flight rate has been established that includes the firm flights plus minimum reflight capability. This flight rate is used for basic contract content for major flight hardware. In addition, a surge flight rate that includes the next level probability flights has been identified. Prepriced contract options for hardware will be used to support surge flight rates. Production base plus surge flight rates are the basis for budget content. Because of long manufacturing lead times, surge flight levels will be reviewed on an annual basis, so surge options will be implemented as soon as firm needs are verified.

The SSME had another year of excellent flight performance, although there was the launch abort of mission 41-D, which resulted from a malfunctioning main fuel valve actuator. Four Shuttle flights were completed with no SSME anomalies which affected flight performance. Certification of the SSME at the 104% thrust level continued and is scheduled for completion early in CY 1985. When completed, the certification program will have demonstrated an equivalent of 40 flights on each of two samples and, by definition, the SSME will then be certified for 20 flights at 104% thrust. The SSME ground test experience now exceeds 1,170 tests totaling approximately 226,000 seconds. Included in these ground tests are 420 tests exceeding 50,000 seconds at the full power level (109%) thrust. Also, during the past year, 46 major components and 3 complete engines were manufactured.

As I noted last summer, we have experienced life design deficiencies at the 109% thrust level, and these deficiencies are primarily in the high pressure turbopump lifetimes. The agency has had in place for sometime a multiphase development program to alleviate these life deficiencies, and that development program has been very successful. During the second quarter of FY 85, we will begin formal certification of improved high pressure pumps, which we expect to demonstrate significant improved life. In addition to direct pump improvements, we also have under way the development of a two-duct hot gas manifold which will improve the operating environment of the pumps. The two-duct manifold represents a modification of one portion of the existing powerhead and, while it will not increase the life of the high pressure pumps, it is expected to give increased operating margin and, consequently, improve safety/reliability of the pumps. The design of the new hot gas manifold is complete, and fabrication of new manifolds has begun. Development testing will begin in FY 1986.

We have had a problem in the past with a shortage of SSME flight hardware. This shortage is primarily with the high pressure pumps. The efforts to improve pump life, noted above, will partially alleviate the shortage, but the agency and the prime SSME contractor, Rocketdyne, have under way an effort to make more efficient the entire engine manufacturing process with emphasis on the high pressure pumps. Included are new and overhauled machine tools, many more digitally-controlled machine tools, a dedicated pump manufacturing area, a dedicated pump overhaul center, additional suppliers of critical piece parts, and an automated system for handling the inspection/anomaly resolution paperwork.

During FY 1984, twelve SRB's, which amounted to six flight sets, were delivered to KSC. In addition, inert SRM and SRB structural components were delivered to the Vandenberg Launch Site (VLS) for assembly of the facility verification vehicle which will be used to verify the vehicle and facility interfaces. The expansion of the existing refurbishment and assembly facilities at KSC to provide the capability of assembling 16 flight sets per year was essentially completed with only minor modifications still to be worked. The incumbent contractor, United Space Boosters, Inc., (USBI) won the recompetition for the assembly and refurbishment of SRB's, and development of larger main parachutes to minimize hardware damage at water impact was completed.

The development of the Filament Wound Case (FWC) for the SRM's achieved several major program milestones during the past year. The full segment development hydrotests were successfully concluded, and design verification data on the composite and composite to metal joint strength were obtained through demonstrating the required margin of safety. Following a Preliminary Design Review, the design and premanufacturing process were fixed, and the processing of the segments for the first flight set was initiated. By the end of the fiscal year, all segments for the first flight from Vandenberg Air Force Base (VAFB) were wound, and all segments for the first static test (DM-6) were manufactured, loaded, and assembled in the test stand for testing at the end of October 1984. In addition, all four case segments for the second static test (DM-7) were manufactured and delivered to Morton-Thiokol for propellant loading. The Structural Test Articles were also delivered to MSFC for testing of dynamic loading under pressure. Significant weight savings were achieved, and increased payload capability resulting from the FWC is now estimated at 4600 lbs. Significant accomplishments were made in recovering from technical problems and schedule difficulties to permit NASA to deliver the first flight set to VAFB in support of the first flight. The assembly of the first FWC development motor was completed in the static test facility, with the firing in early FY 1985.

In addition to the continuation of the FWC development program, the first of three planned parachute drop tests of the FWC drogue parachute was successfully completed, and activity continued to protect the thrust vector control system to reduce hardware damage.

The External Tank (ET) Program has had another exceptionally productive year in 1984. Continued emphasis on cost reduction has resulted in significant savings commitments by the contractor. Plasma arc welding was implemented on two additional tools. The delivery of ten flight units during 1984 included the first unit to be delivered to VAFB. An incentive contract was signed with Martin Marietta Aerospace for the production of tanks through ET-60, and an RFP was released for the production of tanks through ET-120.

The Payload Assist Module (PAM) Program had nine PAM-D flights during FY 1984, and continued development of the PAM-DII. Both of these are commercial programs by McDonnell Douglas Corporation. There were two mission failures -- Westar-VI and Palapa B-2, both on STS-11 in February 1984. Since the failure of the two PAM-D upper stages on the February STS flight, seven PAM-D's have been flown successfully. The resumption of PAM-D flights was permitted only after an extensive failure review process was completed and the probable cause pinpointed and corrected. In addition, seven PAM flights are planned for FY 1985. During FY 1984, NASA led a DOD/NASA/Industry examination of the U.S. state-of-the-art for design, building, testing, and using SRM's containing composite materials. As a result of this examination, and to further enhance confidence, NASA has initiated a SRM Integrity Program to assist industry in further understanding the critical materials and processes used in the manufacture of SRM's.

The STS/Centaur development for both the common Centaur G and the NASA planetary Centaur G Prime vehicles is continuing. The design phase for both configurations has essentially been completed by the successful Preliminary and Critical Design Reviews. The G Prime test vehicle has been fabricated and is presently in structural dynamic tests. G Prime component qualification tests are also proceeding at this time. Fabrication of the flight vehicles for the Galileo and Ulysses missions is under way and is proceeding on or near schedule. The RL-10 engines for these missions have been built, tested, and sent to Convair for installation on the flight vehicles.

During 1984, the Transfer Orbit Stage (TOS), being developed commercially by Orbital Sciences Corporation (OSC) and Martin Marietta Corporation, successfully completed its Preliminary Design Review, Phase I Safety Reviews, and Software Critical Design Review under contract with OSC. NASA technical oversight is being provided by a TOS Project Office at MSFC.

In FY 1985, the TOS development will continue with the Critical Design Review planned in March. The Phase II safety reviews will also be completed.

The Inertial Upper Stage (IUS) launched a DOD mission from the Shuttle in January and Tracking and Data Relay Satellite (TDRS-B) in February 1985. The earlier failure of the IUS in April 1983 was identified as the collapse of the second stage nozzle Techroll Seal (TRS), a flexible ring which allows the nozzle to move and provide directional control. Design changes have been identified and incorporated into the remaining flight vehicles, and full-scale motor verification tests have been conducted by the NASA/DOD industry team.

In 1984, the Orbital Manuevering Vehicle (OMV) preliminary design studies were initiated through a competitive award process with systems studies being conducted by TRW, Martin Marietta Aerospace, and LTV. Orbital Transfer Vehicle (OTV) preliminary concept studies were also awarded in which major systems issues will be addressed particulary relating to utilization at the Space Station. Advanced tether systems applications underwent the first round of engineering analysis in preparation for more detailed studies of the selected candidates. Plans for the Shuttle Derived Launch Vehicle (SDLV) are subject to the results of discussions with the Department of Defense which are now under way.

The hardware development phase of the Tethered Satellite System (TSS) Program was initiated in 1984. This satellite system is a joint U.S./Italian development which will provide a new capability for conducting space experiments in regions remote from the Space Shuttle Orbiter. The objectives of the initial mission are twofold -- to verify the controlled deployment, operation, and retrieval of the TSS and to quantify the interaction between the satellite and tether.

The design and development of the TSS will be continued through Preliminary and Critical Design review stages in 1985 leading to the delivery of a flight article in early 1987. Plans for the first flight are late 1987 or early 1988.

NASA's Expendable Launch Vehicle (ELV) Program reached a milestone in 1984 with the launch of its 401st vehicle since inception of the program in 1960. The most active NASA vehicle, the Delta, was used in four launches during CY 1984 and established a new record of 43 launch successes in a row. In addition, launches of one Scout, one Atlas, and one Atlas Centaur were conducted in 1984. All were successful except the Atlas Centaur launch attempt of one Intelsat communications satellite in June 1984. The vehicle failed to place the spacecraft into its proper transfer orbit. An investigation has been conducted, and testing of recommended corrective measures are under way prior to resumption of launching in early 1985.

Although no NASA funds are being requested to support ELV's in 1985, 12 missions are planned to be launched for other U.S. Government and nongovernment users on a fully reimbursable basis. These vehicles are being used to fulfill NASA commitments made during the transition of Shuttle development and operations.

NASA is proceeding to implement national policy to commercialize ELV's as outlined in President Reagan's Policy NSDD-94 dated May 16, 1983. Three of NASA's ELV's are being considered for commercial operations at this time -- the Delta, the Atlas Centaur, and the Scout. Since we talked to you last year, NASA has solicited proposals for commercial operation of the Scout. This overall effort is proceeding slowly. None of the commercial operators have been successful in marketing any mission users to provide an initial impetus to this new enterprise.

The fabrication of the last major component in the European Spacelab Program, the Instrument Pointing System (IPS), was completed and delivered to KSC at the beginning of FY 1985, while qualification testing continued in Europe. It is in the process of being checked out and integrated with the other Spacelab systems, and the experiments for its maiden voyage and verification on the Spacelab-2 mission to be flown later this year. In the U.S., while the initial Spacelab missions are being carried out, we are continuing to build up our operational capability with the establishment of our logistics systems and inlay of spares, and the completion of the expansion of the Software Development Facility to support the planned flight rate.

In FY 1985, the Hitchhiker development program was begun, and, when completed later this year, will add two small payload carriers to the Spacelab stable which will permit rapid access to space at a reduced cost for many new experimenters. The outfitting of one of the Spacelab pallets for specialized structures technology experiments was also begun this year. In order to handle the planned flight rate, the design and fabrication of a second Payload Operations Control Center (POCC), located at MSFC, was initiated and is planned to be completed in time to support the ASTRO-1 mission in FY 1986.

Prior to the Spacelab-2 mission, the first operational Spacelab mission, Spacelab-3, will be flown using the same basic manned module configuration as Spacelab-1 to carry a series of new experiments into low-Earth orbit. The Environmental Observation Mission-1 (EOM-1), which will carry some of the Spacelab-1 experiments back into orbit, will now be combined with the Environmental Observation Mission-2 (EOM-2) for increased efficiency. This mission will be flown in FY 1986.

Preparations will continue in FY 1985 to conduct specific Space Station-related experiments, including the EVA assembly of structures in early FY 1986, a series on the dynamics of large structures starting in FY 1988, and a series using Hitchhiker to provide basic design data, such as capillary pump performance and plasma solar array interaction, also starting in early FY 1986. In addition, all Spacelab flights will be an invaluable preparation and experience for Space Station.

In Advanced Programs, the OMV preliminary systems design will be accomplished, the OTV preliminary concepts will have been completed, the detailed systems engineering of advanced tether applications will have been fully initiated, and the preliminary design will have been initiated during FY 1985. The base program will continue to conduct studies and advanced developments in satellite services, crew systems, advanced transportation systems, spacecraft systems related to advanced tether applications and geostationary platforms, and land generic space systems capabilities such as artificial intelligence applications to operational problems.

In January 1985, we successfully conducted the first dedicated mission for the Department of Defense.

Current planning for STS reimbursable launches for 1985 includes the launching of 15 communications satellites and two missions for the DOD. The communications satellite customers include Mexico, ARABSAT, USSAT PTY. Ltd., Western Union, AT&T, American Satellite Company, RCA American Communications, Telesat Canada, Hughes Communications Services, Inc., SPACECOM, and others.

In addition, we have received new requests for reservations on the STS in 1987 and beyond from the People's Republic of China, the Government of Italy, and SPACECOM for communications satellites and from the Federal Republic of Germany for a follow-on Spacelab mission.

FY 1986 BUDGET REQUEST

The total budget authority requested for the STS Program for FY 1986 is $3160.9 million. Within this request, an amount of $2701.6 million is requested in the appropriation titled Space Flight, Control, and Data Communications. Activities covered here include Shuttle Production and Operational Capability and Shuttle Operations. $459.3 million is requested in the Research and Development appropriation for Space Transportation Capability Development which provides for Upper Stages, Engineering and Technical Base, Spacelab, Payload Operations and Support Equipment, Advanced Programs, and Tethered Satellite System.

Shuttle Production and Operational Capability

The objectives of thTs program are to provide for the completion of the national fleet of Shuttle Orbiters; the production and capability development of the propulsion systems; the mission preparation, mission control, and launch site capabilities; and the potential changes and upgrading of the STS. To support these objectives, we are requesting $976.5 million in FY 1986. This represents a $516 million reduction from the current FY 1985 estimate.

Orbiter

To continue successful Orbiter production activities in FY 1986, we are requesting $333.6 million. This funding supports both production and logistics activites.

With the flight rate going up and the Orbiter Production Program winding down, there is continued emphasis on the Orbiter Spares Program. The initial increment of structural spares has been defined and negotiated with deliveries scheduled through 1987. This program provides a set of major structural components to be used in the event of damage to an Orbiter, while helping to maintain a production base, and potentially reducing the lead time to build an additional Orbiter, if one should be required in the future.

The procurement of spares and repair capability to support the planned increased flight rate is continuing on schedule. The initial lay-in of spares, which will support up to 12 flights per year, will be completed in 1986. Flight rate spares, test equipment, and repair capability to achieve 24 flights per year are an ongoing activity.

Launch and Mission Support

The budget request calls for $163.9 million for launch and mission support. Major efforts at KSC include activation and readiness of launch Pad B, activation of the third mobile launch platform, and equipment modifications to provide the capability to service the Centaur upper stage for the initial Centaur flights.

Full flight rate capability will be achieved for each component of the ground data systems (flight design, mission control, and simulators). We will use the results of the FY 1985 studies to make a decision on an in-flight refueling capability for the Shuttle Carrier Aircraft (Boeing 747) in FY 1986, satisfying a system requirement. The replacement of equipment dating from the Apollo and Shuttle Design, Development, Test and Evaluation (DDT&E) periods will become a major effort as will the project to extend the operational life of the T-38 training and pilot proficiency aircraft.

Propulsion Systems

In FY 1986, $454.0 million is requested for propulsion systems. Funding for the main engine provides for those activities necessary to support the Orbiter production, flight schedules, and ground testing. Other ongoing activities will include flight spares lay-in, anomaly resolution testing, and continued certification and development testing.

In the SRB Program, we will continue hardware producibility improvements to reduce turnaround time on reusable hardware and continue efforts to reduce hardware damage during water impact. Construction of the new Refurbishment and Assembly Facility at KSC will be completed. The fabrication of FWC segments will continue, and the development testing will be completed. During FY 86, twenty six boosters (13 flight sets) will be delivered to support KSC and VAFB flights.

Production rate of ET's will continue to increase on plan with 12 tanks scheduled for delivery in FY 1986.

Changes and Systems Upgrading

Management, technical flight experiences, and cost reviews of the Space Shuttle program have stressed the need for providing an adequate allowance for changes and modifications which are required in a large, complex, and technically demanding space system. We are requesting funding of $25.0 million in this area to provide the capability to undertake those changes and upgrading of flight and ground systems needed in the Space Shuttle program. Improvements to system safety, reliability, performance, and cost effectiveness are the key objectives.

Shuttle Operations

Shuttle operations direct appropriated funds are combined with reimbursements received from other U.S. government, commercial, and international customers to support the procurement of flight hardware for launch and flight operation requirements. For FY 1986, $1725.1 million is requested in direct appropriations. The Shuttle operations budget request includes funds in three principal areas -- flight operations, flight hardware, and launch and landing operations. This anticipates the receipt of about $400 million in Shuttle reimbursements.

Flight Operations

The flight operations request of $425.2 million provides for the maintenance and operation of the onboard avionics software, mission control systems, as well as astronaut training and flight proficiency aircraft and simulators. It also includes sustaining engineering required to integrate all flight elements (including contractor support at the launch sites) and to assure systems safety. The amount required over the core of the Shuttle Avionics Integration Laboratory (SAIL) is provided to test and verify operations software and hardware modifications. Flight operations also include Getaway Special support managed by the Goddard Space Flight Center and the payload integration activities at Johnson Space Center. At JSC, support is included for flight crew mission requirements and safety certification, operations and maintenance support, printing, equipment rentals, and materials for base operations activities.

Flight Hardware

$964.0 million is being requested for flight hardware in FY 1986. Orbiter flight spares and crew equipment spares are based on calculations involving flight rates, maintenance schedules, operational hours, turnaround times, and procurement lead times for spares. The structural spares program, which was initiated in FY 1983, is continuing with deliveries of all major modules scheduled by FY 1987. Main engine hardware provides for manufacturing and delivery of overhauled engines and engine component spares.

Launch and Landing Operations

Launch and landing operations funding of $335.9 million in FY 1986 provides for manpower to process and integrate elements (SRB, ET, Orbiter, payloads) prior to launch, to retrieve the SRB's for refurbishment, and for orbiter landing and return for future flights. Funding also supports sustaining engineering, logistics, launch processing systems, and facility and equipment maintenance. Also included are the projected savings resulting from the consolidated base operations and the SPC's at KSC.

In FY 1986, we plan to achieve the launch of Galileo and Ulysses in the same launch window (six days apart.)

Expendable Launch Vehicles

Eight expendable launches are planned in 1986 in continued support of other U.S. Government and nongovernment users. The vehicle systems being used have completed production and are in inventory to fill user demands. This program is being phased out with the potential for operation by commercialized entrepreneurs.

RESEARCH AND DEVELOPMENT

Upper Stages

In FY 1986, $122.0 million is requested for upper stage development, procurement, and operational requirements.

These funds will provide for accomplishing the first two Centaur/STS missions -- Galileo and Ulysses in May 1986. In addition, continued procurement and operational support of the IUS for TDRS-D, Centaur/STS vehicle for the Venus Radar Mapper (VRM), TDRS-E and F, one PAM-A vehicle for the Advanced Communications Technology Satellite (ACTS), Upper Stage Program monitoring for PAM and TOS, and efforts related to an SRM Integrity Program, are included in the fund request. Although we have baselined our budget planning on the Centaur/STS vehicle for TDRS-E and F, and on the TOS for MGCO, we plan to hold a competition among the upper stages capable of performing these missions.

Engineering and Technical Base

In FY 1986, a funding level of $109.7 million is requested to support the core engineering base necessary to sustain a continuing capability in space transportation and manned flight. The engineering and technical base (ETB) budget line was established in FY 1983, in response to the Subcommittee on Space Science and Applications action to "assure adequate support of the research and development institutions" specifically addressing "the period during which Shuttle operations are beginning and Shuttle development is completed ....." As you may recall, while the Civil Service staffing configuration of the NASA Centers differ from Center to Center, more than three-fourths of the staff are professionals. Most of the necessary technical support for our working Civil Service professionals is provided through support contractors and other procurements funded by the ETB budget.

The ETB budget provides the support necessary to operate a core of Research and Development (R&D) facilities and laboratories for a five-day, one-shift operation at designated OSF Centers. The expert contractor technicians and operators provided in this budget line item, plus other support, such as consumables and equipment, assure the effective operation of a core capability within the OSF Centers. The Civil Service professionals rely on the technical facilities and operations, in order to conduct R&D tests and analysis.

Spacelab

The Spacelab FY 1986 budget request of $96.7 million dollars will complete most of the development program in the U.S. and primarily be used to integrate and operate the Spacelab system. The procurement of additional flight hardware to support the planned flight rate and the Dedicated Discipline Laboratory (DDL) missions will continue in FY 1986. The DDL's will save costs by permitting certain payloads to be reflown without deintegration and reintegration between missions. The FY 1986 funding will be used to complete the Spacelab Pallet System which will permit the mixed cargo use of the Igloo Pallet configuration for the viewing of the Halley's comet with the ASTRO-1 mission in that year.

Spacelab operations in FY 1986 will require funding for the operation of both the POCC's, the ground operations for integration and deintegration of missions, the analytical and software integration, the sustaining engineering, and the operation of the training facilities. The missions which are currently planned to be flown in FY 1986 include the first Spacelab Life Sciences Mission, which will use the manned module, the first dedicated reimbursable mission for West Germany, the combined EOM-1/EOM-2, and a series of smaller payloads such as those carried on the Multipurpose Experiment Support Structures. Also planned in FY 1986 are the first Hitchhiker missions in both the Hitchhiker-Goddard and Hitchhiker-Marshall configurations.

Payload Operations and Support Equipment

The payload operations support equipment program request of $63.9 million provides for payload services which are required beyond the basic standard Shuttle services. Payload operations provides unique hardware, analysis, and STS launch site services. Payload operations funding in FY 1986 is required to furnish continued payload services for currently scheduled NASA launches. Payloads to receive support include Galileo, VRM, Ulysses, TDRS, Space Telescope, and Spacelabs 2 and 3. The funding will also support the investment to complete the POCC located at JSC to support Spacelab missions and provide additional Multi-Mission Payload Support Equipment (MMPSE). The equipment is required to integrate, check out, transport, and provide Orbiter interface to an increasing number and variety of payloads and to provide operational economics through standardization and flexibility.

Advanced Programs

Our requested advanced programs budget for FY 1986 is $21 0 million. Our major emphasis will continue to be placed on satellite services, advanced transportation systems, advanced tether systems applications, geostationary platforms, crew systems, and generic new space systems capabilities.

The advanced work on Shuttle Derived Launch Vehicles (SDLV's) and related advanced developments will continue to be pursued. The Aeroassist Flight Experiment will be initiated in a joint agency program with the Office of Aeronautics and Space Technology to explore aerobraking technologies and techniques for potential future system use on reusable OTV's.

We will continue to conduct a few inexpensive, but critical, flight experiments to demonstrate new national STS capabilities aimed at developing customer confidence in connection with satellite services and orbital operations, such as the Experimental Assembly of Structures in Extravehicular Activity (EASE) and the Assembly Concept for Construction of Erectable Space Structures (ACCESS). We will also be demonstrating a voice-controlled system for the Shuttle closed circuit television which will enhance astronaut productivity and simplify payload operations.

Orbital Maneuvering Vehicle

Our requested funding for the OMV for FY 1986 is $25.0 million. The OMV, which is a reusable, remotely-piloted system, represents a significant extension of capability for the STS, as well as very valuable space infrastructure element for the Space Station. With this FY 1986 initiation, the OMV will be available for flight use in 1990.

Tethered Satellite System

The $21.0 million requested for FY 1986 will be used for continued design and development and fabrication of the flight deployment system planned for flight in 1988.

THE FUTURE

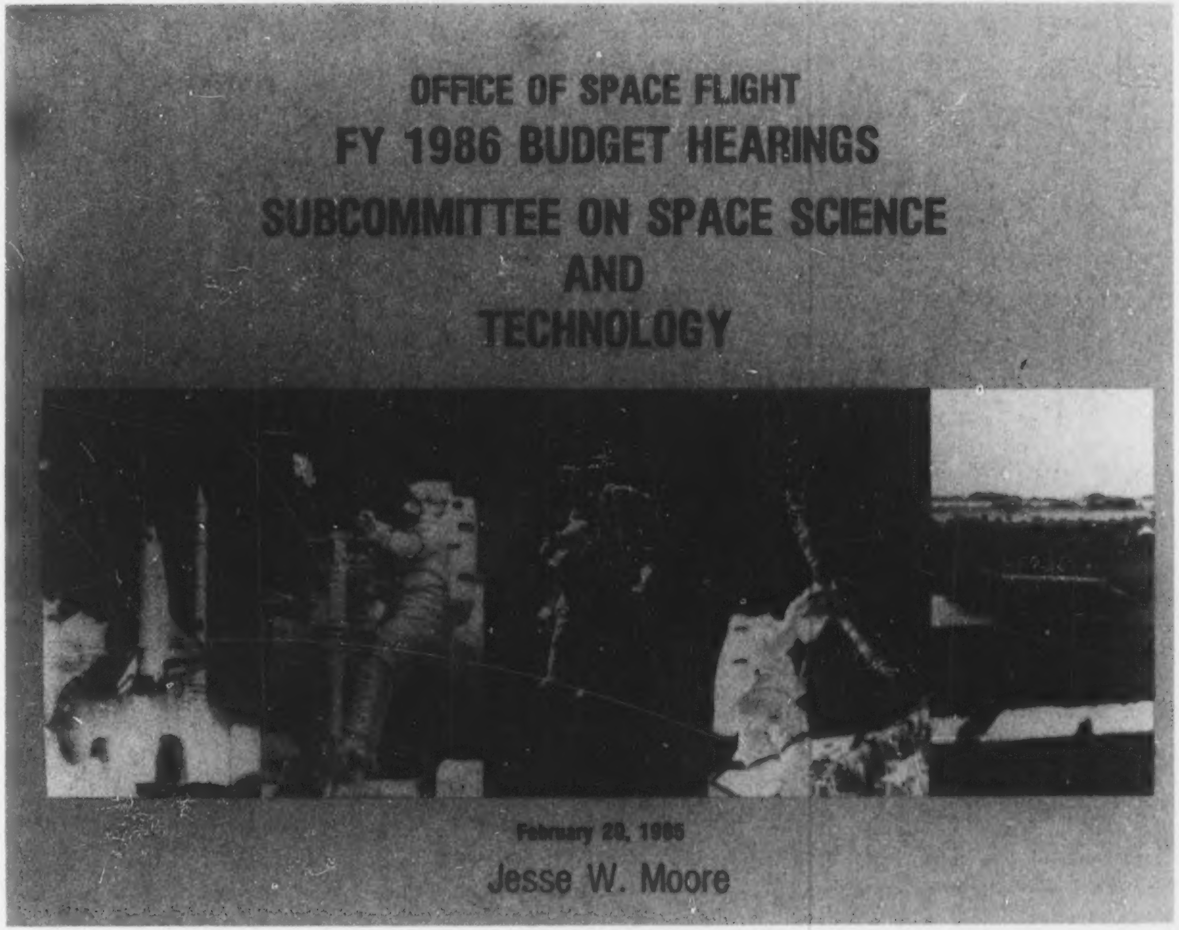
We are understandably proud of the Nation's Space Transportation System and the STS team's many mission accomplishments and our demonstrated capability to repair, retrieve, and refuel spacecraft. The success of man and machine capability in these missions once again demonstrates the soundness of the President's Space Station program.

The STS team will continue to vigorously pursue improvement in the efficiency, reliability, and flexibility of the STS and ensure that our organization provides the best possible customer support. With your help, the management challenges that lie ahead in bringing the system to full operational and cost-effective use will be met.

We are determined to continue to help this Nation provide leadership in space transportation. To provide routine access to space at the lowest cost, we are working aggressively to meet the projected flight rate in a cost-effective manner with less total manpower and less total annual expenditures.

The space program has made many significant contributions to the Nation's technological capabilities. The future possibilities for manned operations in geostationary regimes, advanced lunar base operations and exploration, and explorations within our solar system represent new and exciting opportunities -- not only for the United States but also for our international partners. Our dedicated team looks forward to the future and the challenges of fully utilizing the versatile capabilities of the STS including the critical interface with the multinational Space Station.

With your help, we look forward to a challenging and rewarding future.



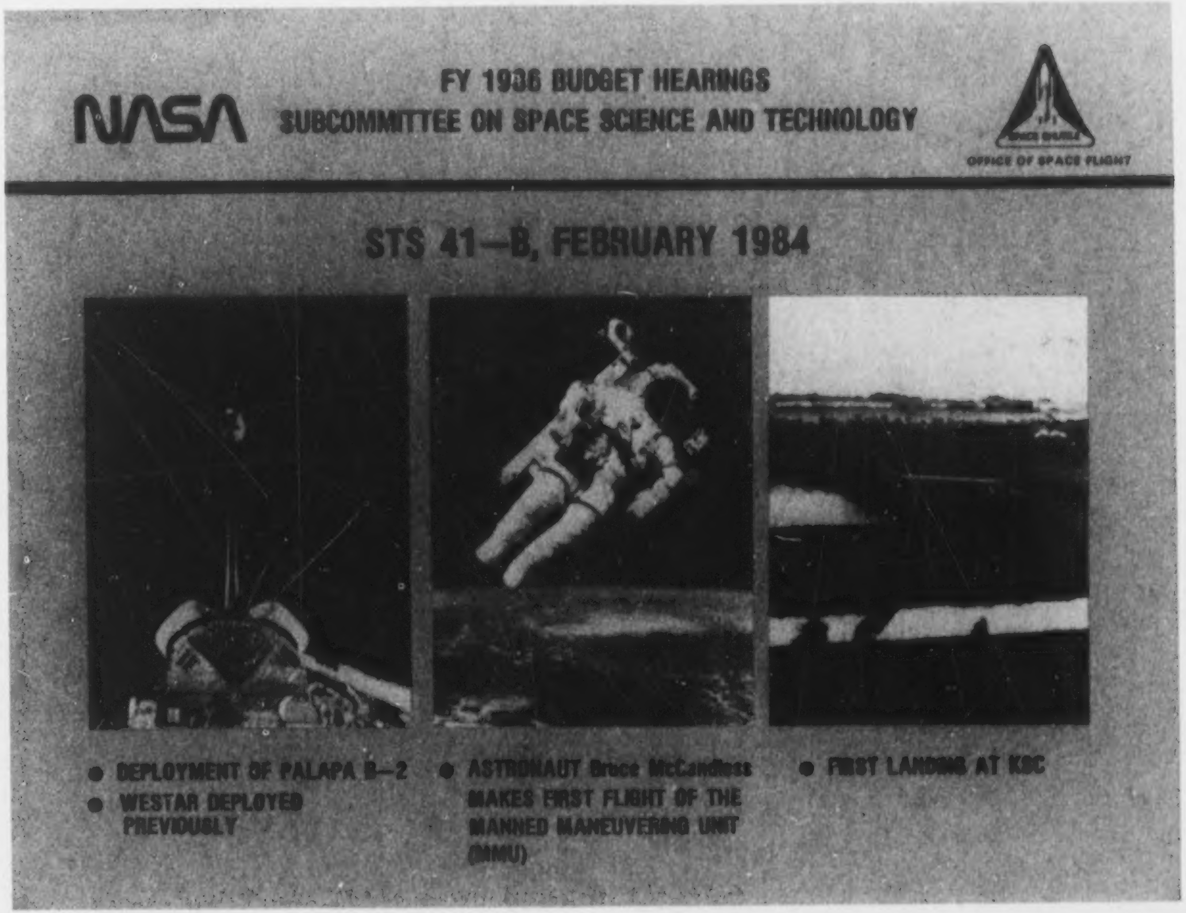
OFFICE OF SPACE FLIGHT

FY 1986 BUDGET HEARINGS

SUBCOMMITTEE ON SPACE SCIENCE
AND
TECHNOLOGY

February 28, 1985

Jesse W. Moore



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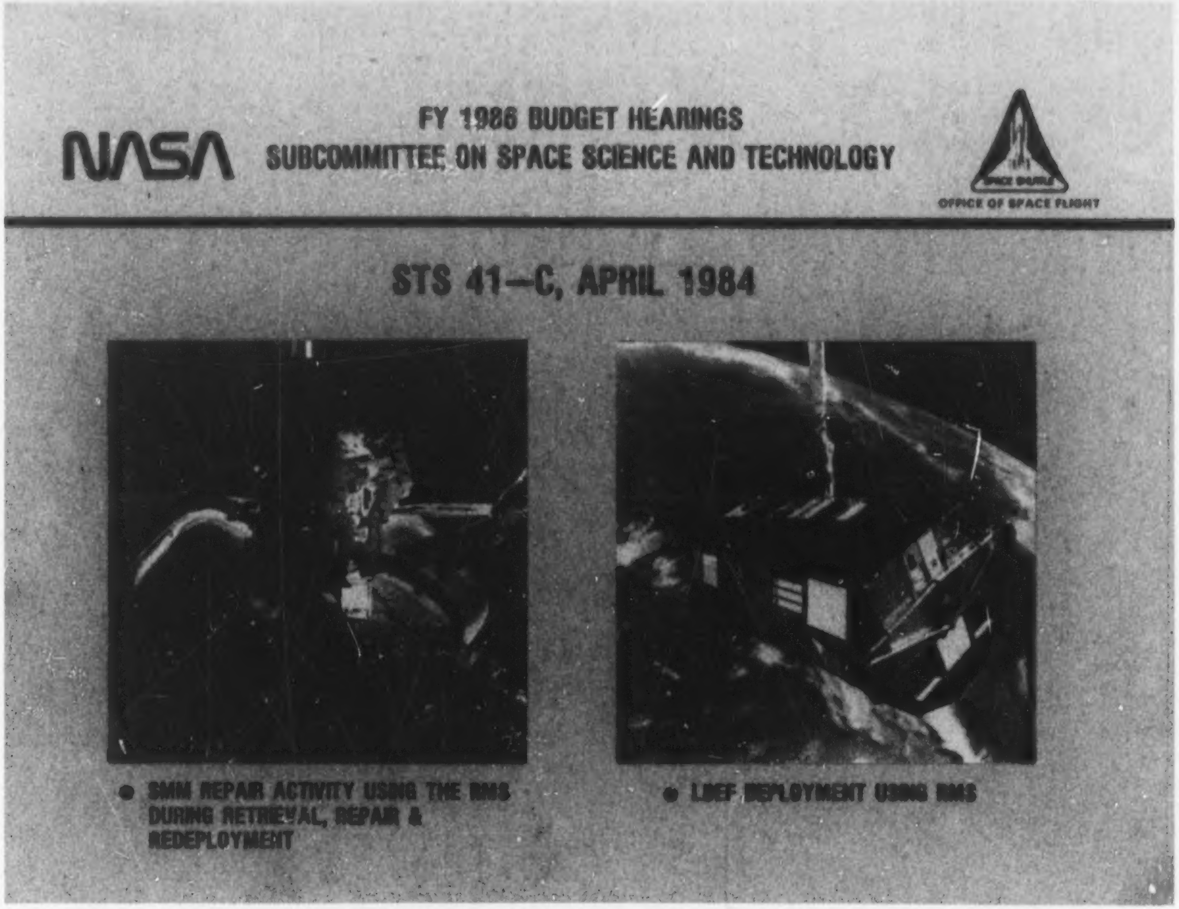
FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

OFFICE OF SPACE FLIGHT

STS 41—B, FEBRUARY 1984

- DEPLOYMENT OF PALAPA B—2
- WESTAR DEPLOYED PREVIOUSLY
- ASTRONAUT Bruce McCandless MAKES FIRST FLIGHT OF THE MANNED MANEUVERING UNIT (MMU)
- FIRST LANDING AT KSC



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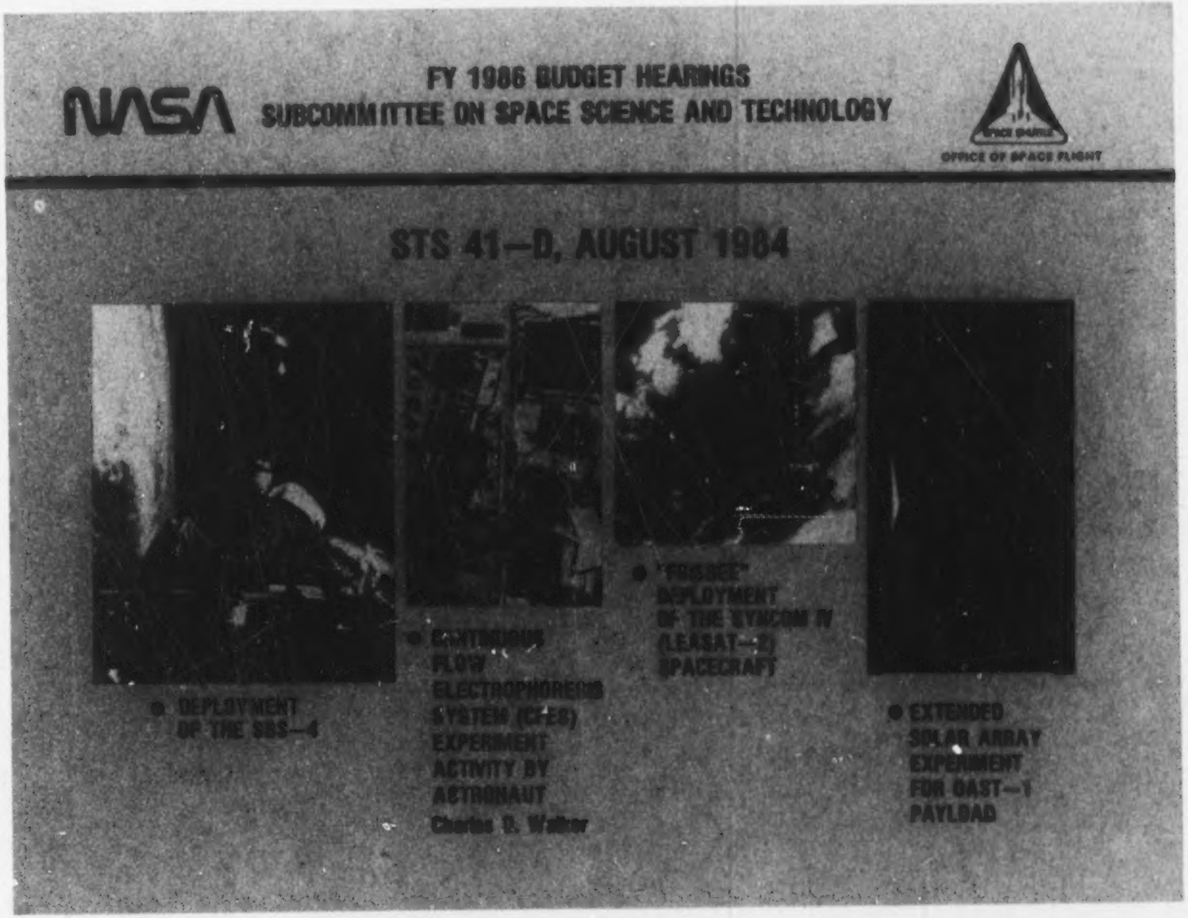
FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

OFFICE OF SPACE FLIGHT

STS 41—C, APRIL 1984

- SMM REPAIR ACTIVITY USING THE RMS DURING RETRIEVAL, REPAIR & REDEPLOYMENT
- LDEF DEPLOYMENT USING RMS

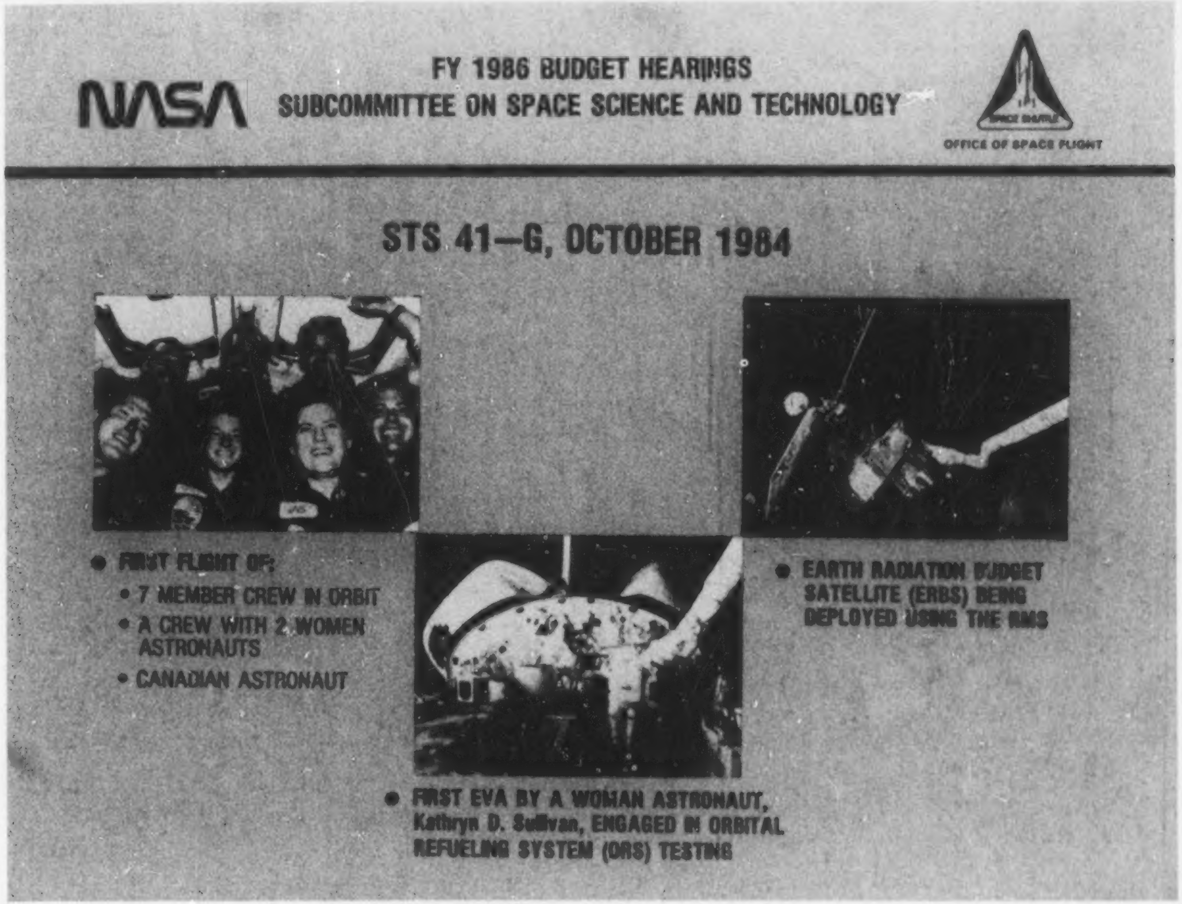


FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

OFFICE OF SPACE FLIGHT

STS 41—D, AUGUST 1984

- DEPLOYMENT OF THE SBS—4
- CONTINUOUS FLOW ELECTROPHORESIS SYSTEM (CFES) EXPERIMENT ACTIVITY BY ASTRONAUT Charles D. Walker
- "FRISBEE" DEPLOYMENT OF THE SYNCOM IV (LEASAT—2) SPACECRAFT
- EXTENDED SOLAR ARRAY EXPERIMENT FOR OAST—1 PAYLOAD



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FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

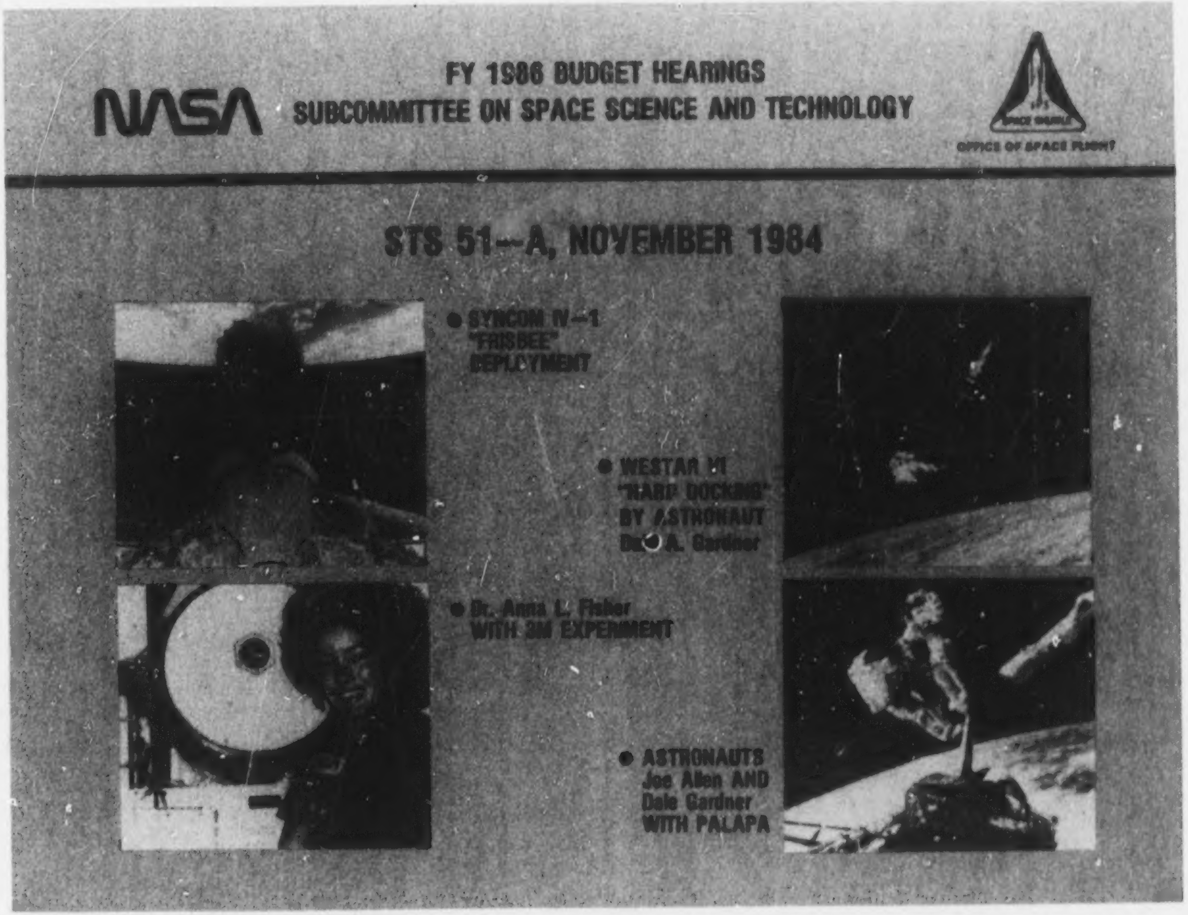
OFFICE OF SPACE FLIGHT

STS 41—G, OCTOBER 1984

- FIRST FLIGHT OF:
  - 7 MEMBER CREW IN ORBIT
  - A CREW WITH 2 WOMEN ASTRONAUTS
  - CANADIAN ASTRONAUT

- FIRST EVA BY A WOMAN ASTRONAUT, Kathryn D. Sullivan, ENGAGED IN ORBITAL REFUELING SYSTEM (ORS) TESTING

- EARTH RADIATION BUDGET SATELLITE (ERBS) BEING DEPLOYED USING THE RMS



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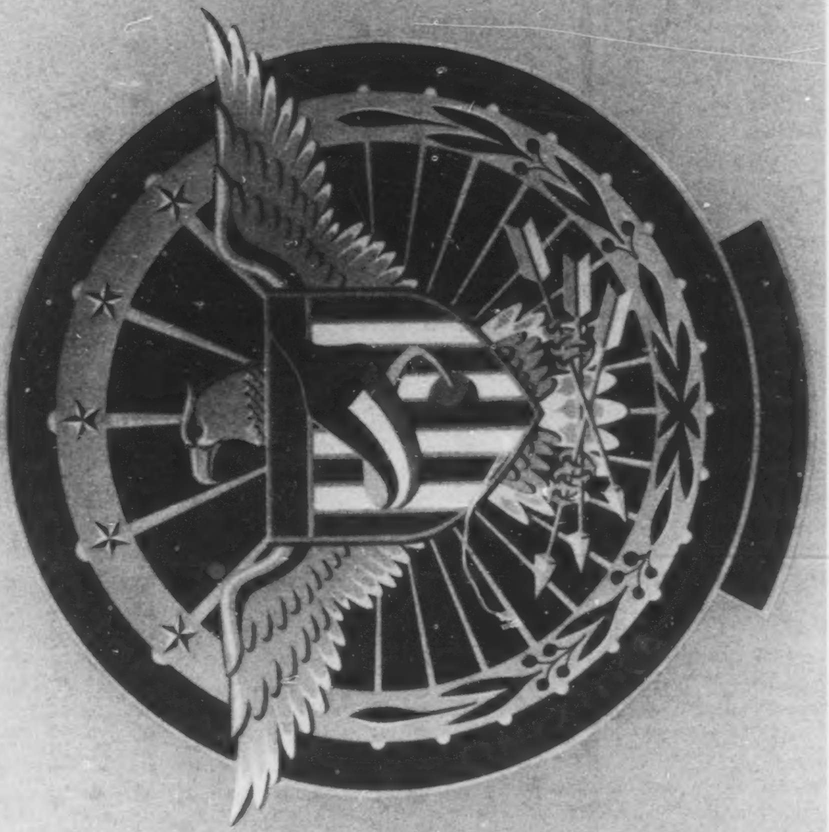
FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

SPACE SHUTTLE
OFFICE OF SPACE FLIGHT

STS 51—A, NOVEMBER 1984

- SYNCOM IV—1 "FRISBEE" DEPLOYMENT
- WESTAR VI "HARD DOCKING" BY ASTRONAUT Da[illegible] A. Gardner
- Dr. Anna L. Fisher WITH 3M EXPERIMENT
- ASTRONAUTS Joe Allen AND Dale Gardner WITH PALAPA



STS 51—C

NASA FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY
OFFICE OF SPACE FLIGHT

HIGHLIGHTS OF PLANNED FY 1985 MISSIONS

- LONG DURATION EXPOSURE FACILITY RETRIEVAL
- 2 DEDICATED SPACELAB FLIGHTS
    - IGLOO/PALLET CONFIGURATION
    - INSTRUMENT POINTING SYSTEM
- 2 TRACKING AND DATA RELAY SATELLITES
- FIRST FLIGHT OF SPARTAN
- 8 COMMERCIAL COMMUNICATIONS SATELLITES
- REFLIGHT OF CONTINUOUS FLOW ELECTROPHORESIS EXPERIMENT
- FIRST FLIGHT OF ORBITER ATLANTIS
- 10 STS MISSIONS

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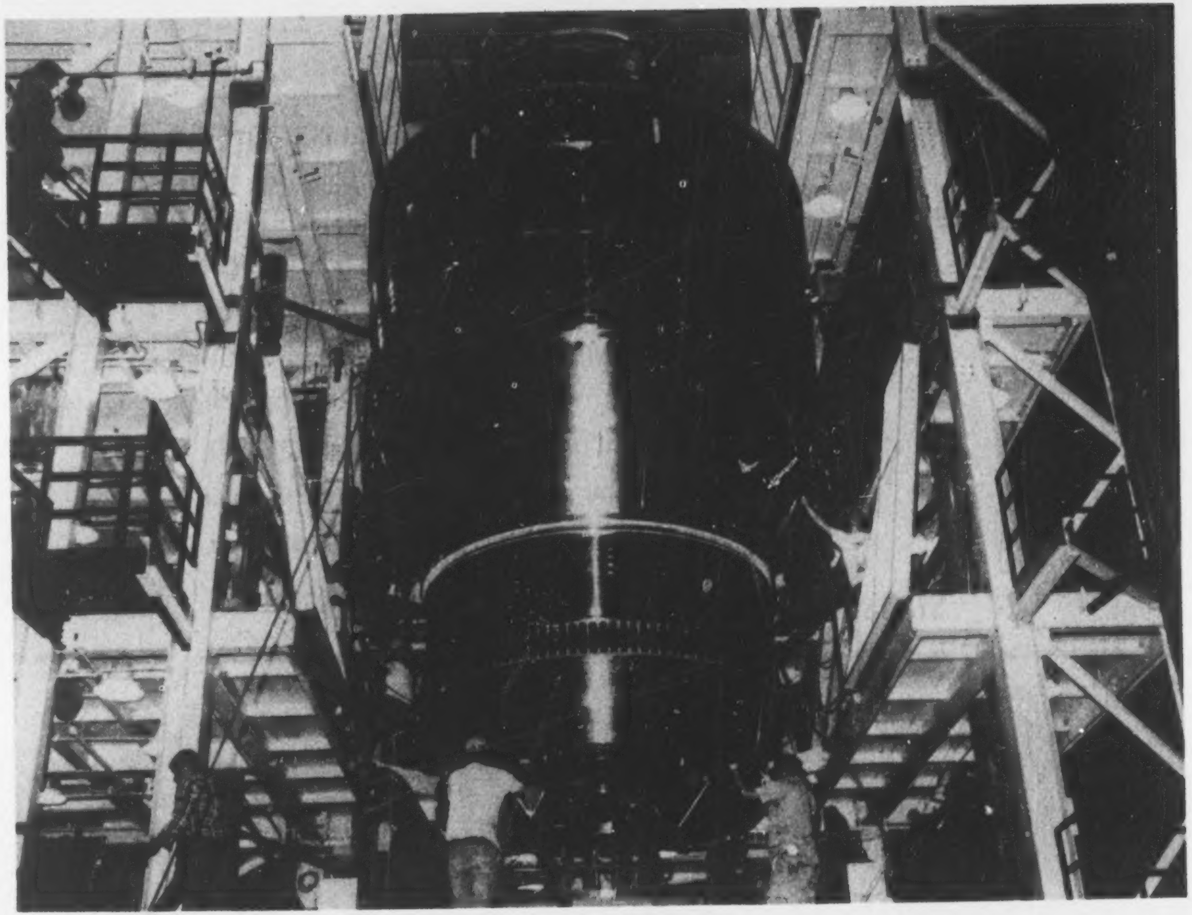
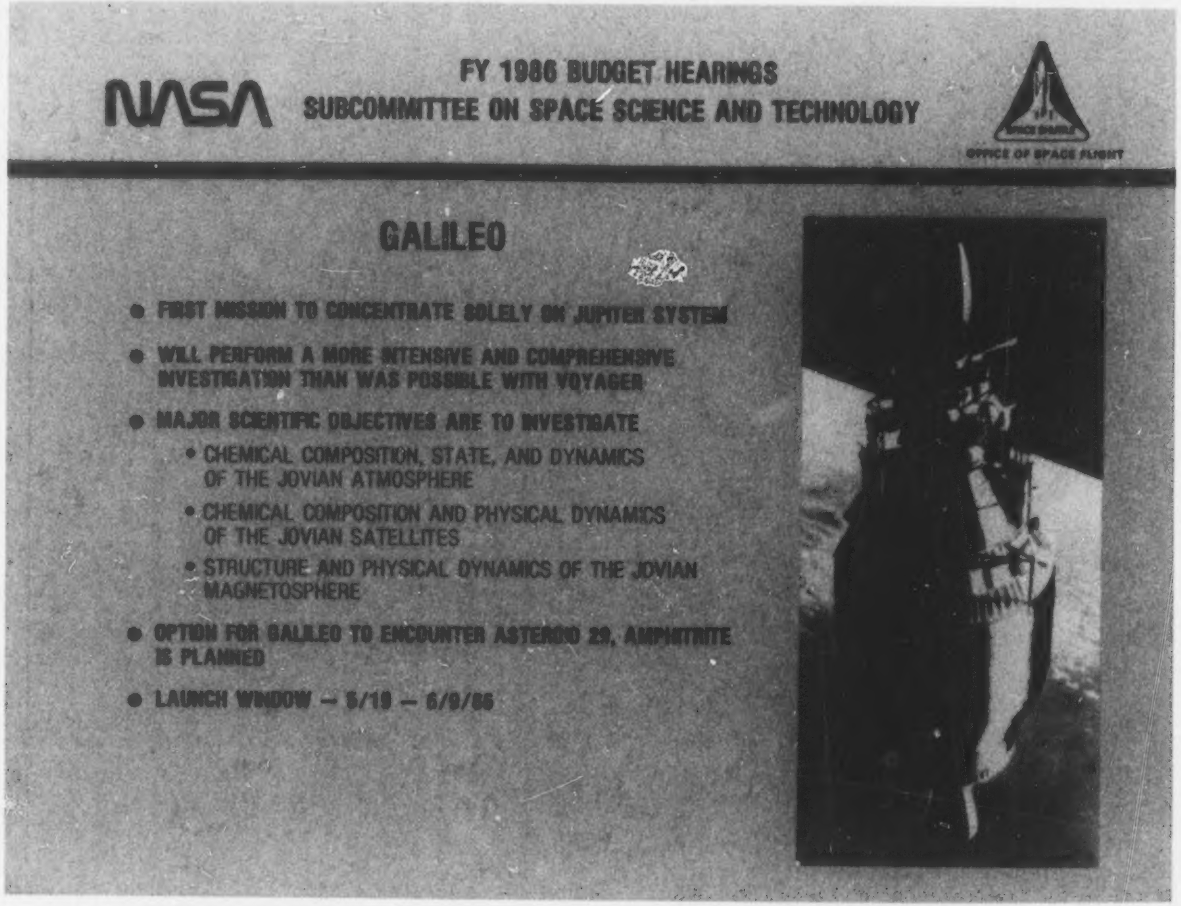
FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

OFFICE OF SPACE FLIGHT

HIGHLIGHTS OF PLANNED FY 1986 MISSIONS

- 11 COMMERCIAL COMMUNICATIONS SATELLITES
- COMMERCIAL DEDICATED SPACELAB FLIGHT
- 1st LAUNCH FROM VANDENBERG LAUNCH SITE
- 1st LAUNCH FROM PAD B, KSC
- ASTRO LAUNCH FOR HALLEY'S COMET OBSERVATION
- DUAL PLANETARY LAUNCHES — GALILEO, ULYSSES
- HUBBLE SPACE TELESCOPE LAUNCH
- ELECTROPHORESIS OPERATIONS IN SPACE, 3M MATERIALS PROCESSING EXPERIMENT
- SPACE FLIGHT PARTICIPANT MISSION
- 14 STS MISSIONS





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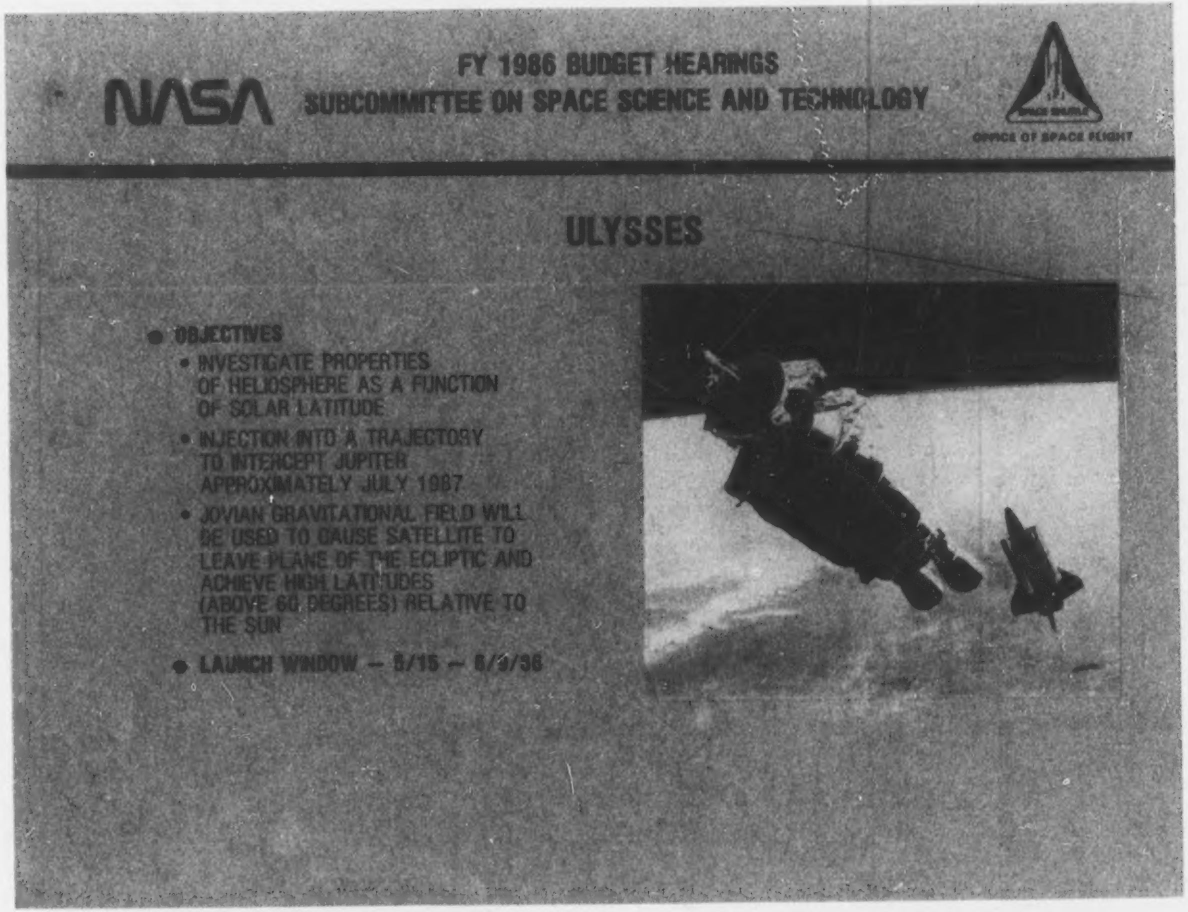
FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

OFFICE OF SPACE FLIGHT

GALILEO

- FIRST MISSION TO CONCENTRATE SOLELY ON JUPITER SYSTEM
- WILL PERFORM A MORE INTENSIVE AND COMPREHENSIVE INVESTIGATION THAN WAS POSSIBLE WITH VOYAGER
- MAJOR SCIENTIFIC OBJECTIVES ARE TO INVESTIGATE
  - CHEMICAL COMPOSITION, STATE, AND DYNAMICS OF THE JOVIAN ATMOSPHERE
  - CHEMICAL COMPOSITION AND PHYSICAL DYNAMICS OF THE JOVIAN SATELLITES
  - STRUCTURE AND PHYSICAL DYNAMICS OF THE JOVIAN MAGNETOSPHERE
- OPTION FOR GALILEO TO ENCOUNTER ASTEROID 29, AMPHITRITE IS PLANNED
- LAUNCH WINDOW — 5/19 — 6/9/86

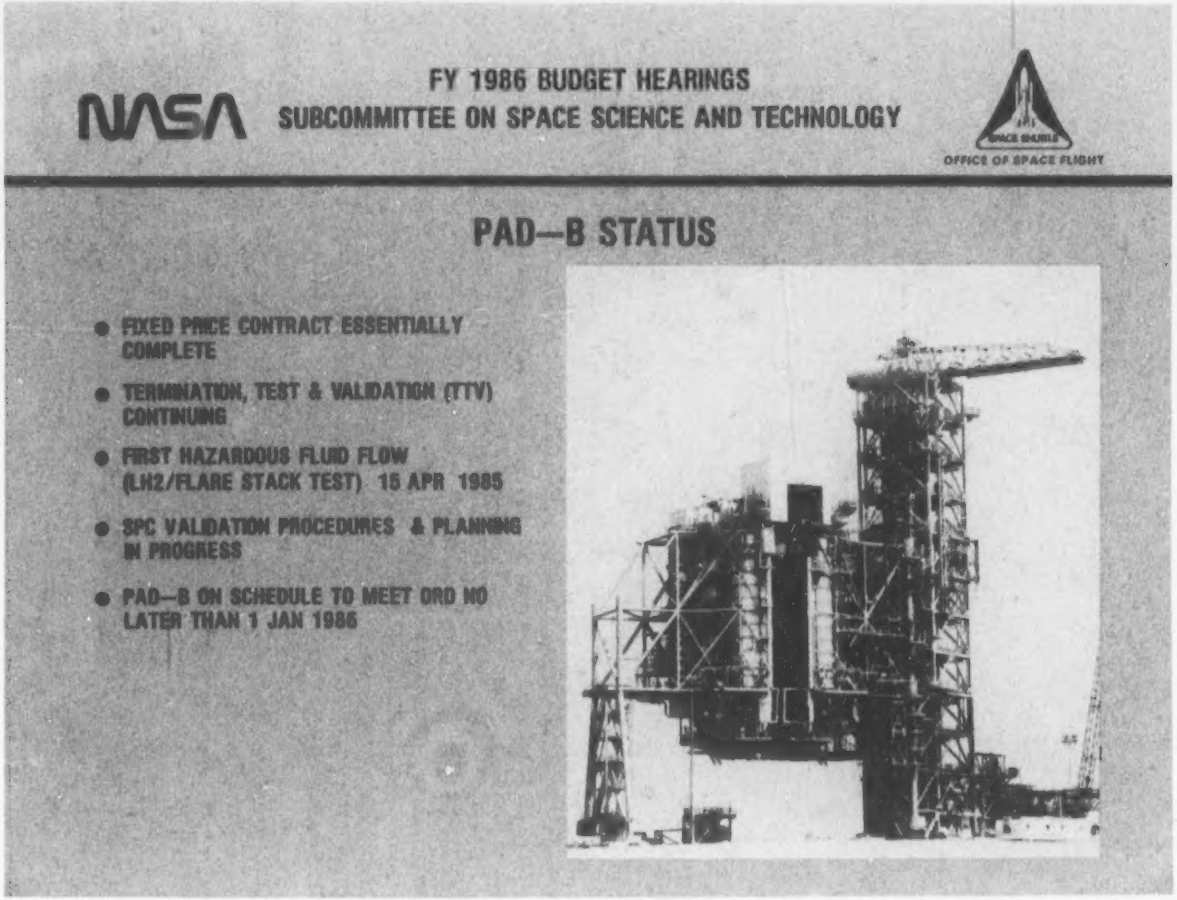


NASA
OFFICE OF SPACE FLIGHT
SPACE SHUTTLE

FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

ULYSSES

- **OBJECTIVES**
  - INVESTIGATE PROPERTIES OF HELIOSPHERE AS A FUNCTION OF SOLAR LATITUDE
  - INJECTION INTO A TRAJECTORY TO INTERCEPT JUPITER APPROXIMATELY JULY 1987
  - JOVIAN GRAVITATIONAL FIELD WILL BE USED TO CAUSE SATELLITE TO LEAVE PLANE OF THE ECLIPTIC AND ACHIEVE HIGH LATITUDES (ABOVE 60 DEGREES) RELATIVE TO THE SUN
- **LAUNCH WINDOW — 5/15 — 6/9/86**



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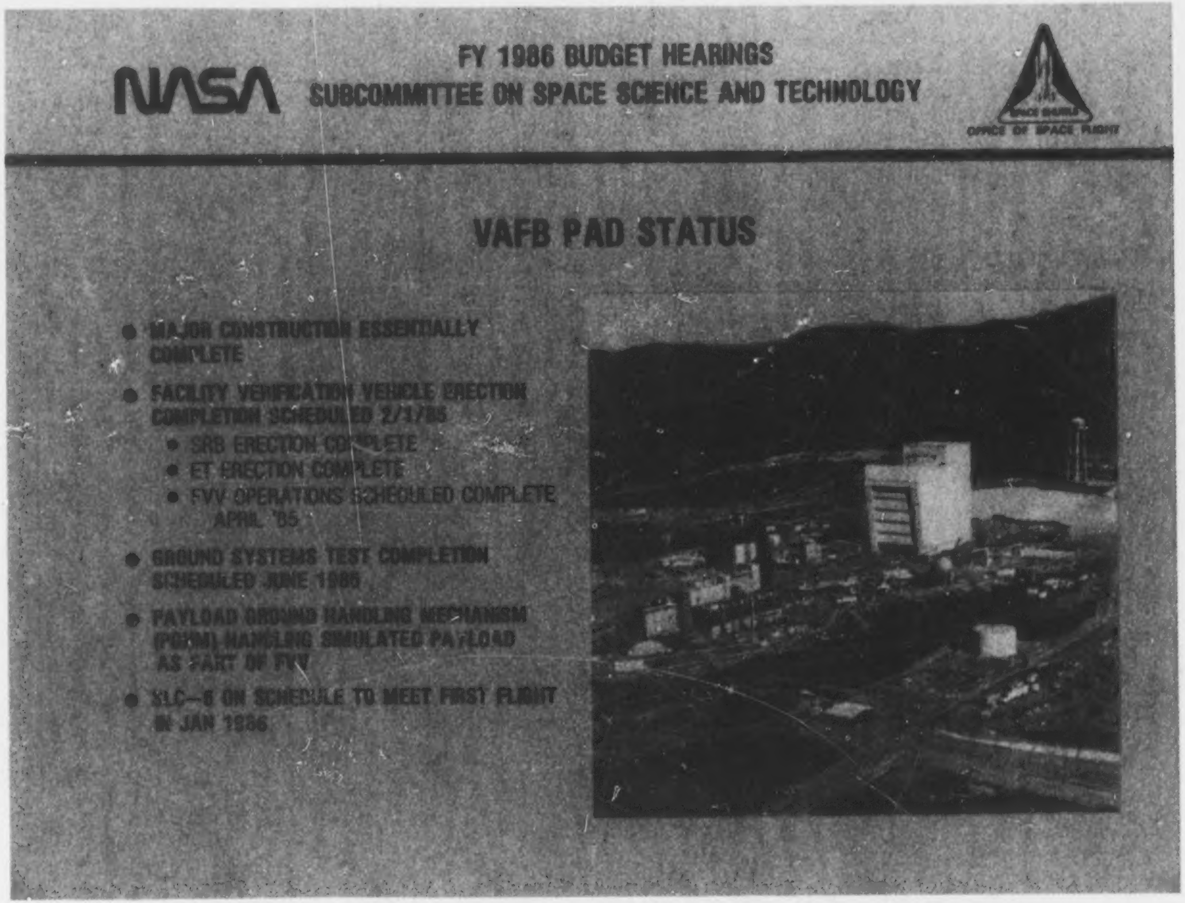
FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

OFFICE OF SPACE FLIGHT

PAD—B STATUS

- FIXED PRICE CONTRACT ESSENTIALLY COMPLETE
- TERMINATION, TEST & VALIDATION (TTV) CONTINUING
- FIRST HAZARDOUS FLUID FLOW (LH2/FLARE STACK TEST) 15 APR 1985
- SPC VALIDATION PROCEDURES & PLANNING IN PROGRESS
- PAD—B ON SCHEDULE TO MEET ORD NO LATER THAN 1 JAN 1986



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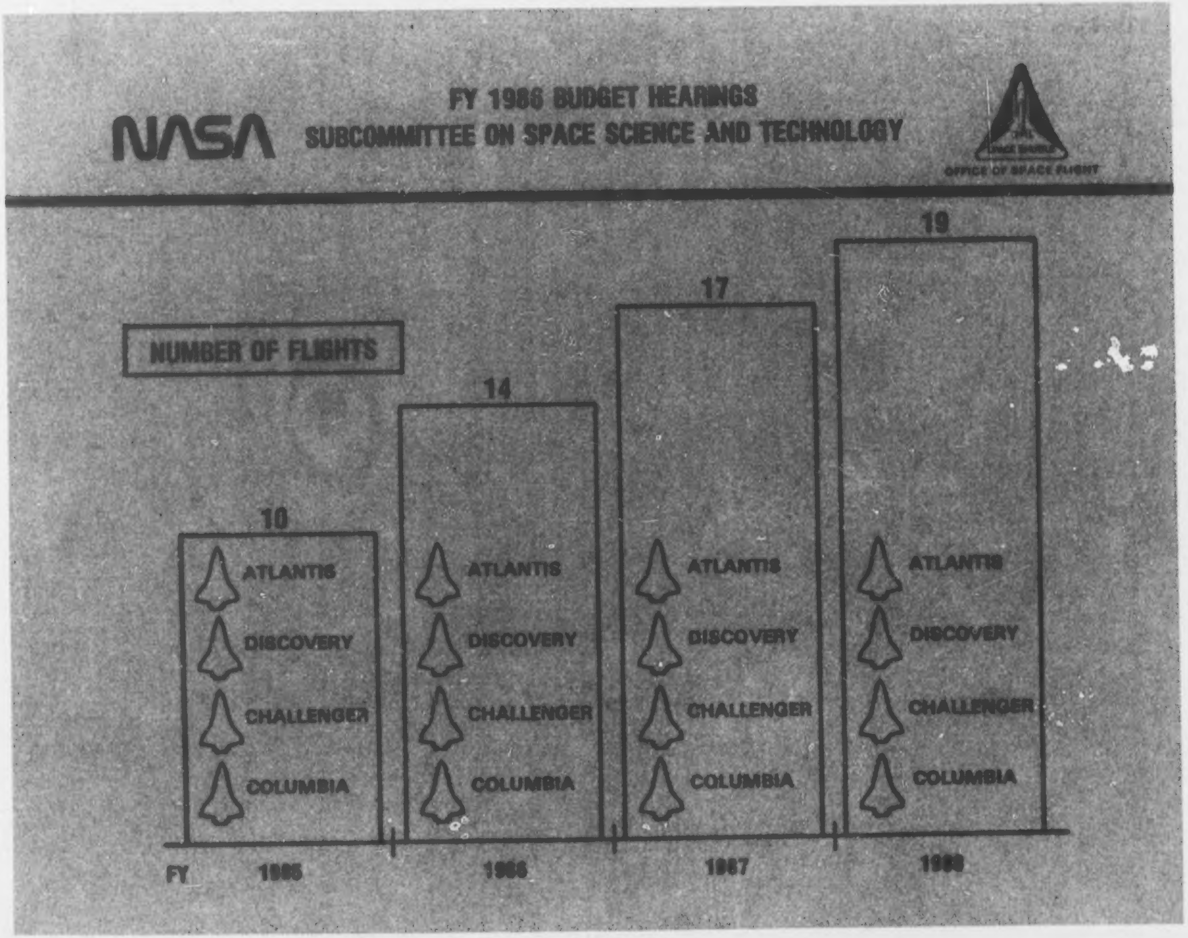
FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

SPACE SHUTTLE
OFFICE OF SPACE FLIGHT

VAFB PAD STATUS

- MAJOR CONSTRUCTION ESSENTIALLY COMPLETE
- FACILITY VERIFICATION VEHICLE ERECTION COMPLETION SCHEDULED 2/1/85
    - SRB ERECTION COMPLETE
    - ET ERECTION COMPLETE
    - FVV OPERATIONS SCHEDULED COMPLETE APRIL '85
- GROUND SYSTEMS TEST COMPLETION SCHEDULED JUNE 1985
- PAYLOAD GROUND HANDLING MECHANISM (PGHM) HANDLING SIMULATED PAYLOAD AS PART OF FVV
- SLC—6 ON SCHEDULE TO MEET FIRST FLIGHT IN JAN 1986



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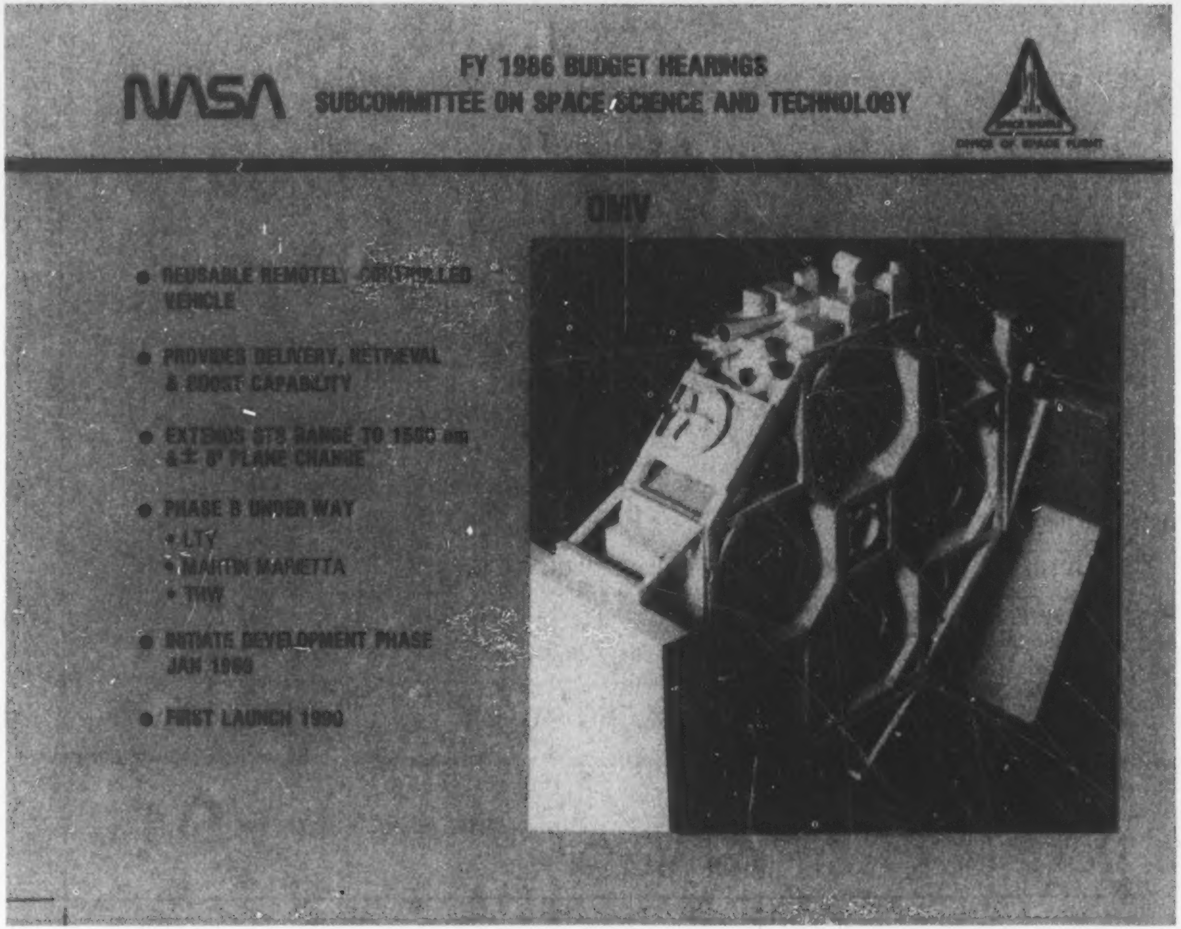
FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

OFFICE OF SPACE FLIGHT

NUMBER OF FLIGHTS



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FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

SPACE SHUTTLE
OFFICE OF SPACE FLIGHT

OMV

- REUSABLE REMOTELY CONTROLLED VEHICLE
- PROVIDES DELIVERY, RETRIEVAL & BOOST CAPABILITY
- EXTENDS STS RANGE TO 1500 nm & ± 8° PLANE CHANGE
- PHASE B UNDER WAY
  - LTV
  - MARTIN MARIETTA
  - TRW
- INITIATE DEVELOPMENT PHASE JAN 1986
- FIRST LAUNCH 1990

FY 1986 BUDGET HEARINGS
SUBCOMMITTEE ON SPACE SCIENCE AND TECHNOLOGY

OFFICE OF SPACE FLIGHT

FY 1986 BUDGET SUMMARY

SUMMARY OF RESOURCES REQUIREMENTS (MILLIONS OF DOLLARS)	1984 ACTUAL	1985 CURRENT ESTIMATE	1986 BUDGET ESTIMATE
SPACE FLIGHT, CONTROL & DATA COMMUNICATIONS	**3098.3**	**2806.1**	**2701.6**
SHUTTLE PRODUCTION & OPERATIONS CAPABILITY	1646.3	1492.1	976.5
SPACE TRANSPORTATION OPERATIONS	1452.0	1314.0	1725.1
SHUTTLE OPERATIONS	(1402.0)	(1314.0)	(1725.1)
EXPENDABLE LAUNCH VEHICLES	(50.0)	(—)	(—)
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT PROGRAM	**431.7**	**351.4**	**459.3**
SPACELAB	111.0	58.3	96.7
UPPER STAGES	143.2	92.4	122.0
ENGINEERING & TECHNICAL BASE	93.1	105.7	109.7
PAYLOAD OPERATIONS & SUPPORT EQUIPMENT	59.6	56.3	63.9
ADVANCED PROGRAMS	21.5	20.5	21.0
TETHERED SATELLITE SYSTEM	3.3	18.2	21.0
ORBITAL MANEUVERING VEHICLE	—	—	25.0

OPERATIONS

QUESTION M-1:

This past summer, Mr. Beggs announced the creation of a Shuttle Operations Strategic Planning Group that will advise you on the extent to which Space Shuttle operations should be "fenced" from the rest of NASA's activities. Please summarize the status of this planning group's activities and any conclusions that it may have reached.

ANSWER M-1:

The Shuttle Operations Strategic Planning Group and its subpanel, the Shuttle Operations Fencing Team, concluded their studies and reported to Mr. Beggs in March 1985. The principal conclusions from these studies are:

(1) The operation of the Shuttle should be retained in NASA for the foreseeable future.

(2) The Shuttle Operations new Congressional budget structure established in FY 84 and the reprogramming controls imposed within NASA and by Congress effectively "fence" the operations costs.

(3) The reorganizations made at the NASA Centers in 1983, in conjunction with the consolidation of support contractors at KSC, Base Operations Contractor and Shuttle Processing Contractor (BOC and SPC), and JSC, Space Transportation Systems Operations Contractor and Flight Equipment Processing Contractor (STSOC and FEPC), effectively delineate the roles and responsibilities of the Shuttle managers and contractors and "fence" the operations.

(4) The Shuttle operations facilities are basically dedicated and not shared with other programs.

In summary, The Strategic Planning Group concluded that NASA should not disturb the Shuttle management, budget, organizational, or facilities structures as NASA is deemed best suited to operate the Shuttle, and the operations within the Agency are effectively "fenced."

QUESTION M-2:

What success has NASA had in the past year in reducing Orbiter turnaround time? What are your improvement goals for the current fiscal year:

ANSWER M-2:

In the past year NASA has successfully reduced Orbiter turnaround time from over 80 workdays down to 53 workdays. Our goal is to further reduce turnaround time down to 35 workdays, by early 1986.

QUESTION M-3:

Last year the FAA revised its notification procedures to airman before Shuttle launches and landings. What has been the history of airspace intrusions since the new procedures have gone into effect?

ANSWER: M-3

Since the airspace intrusion during STS 41-D, more active measures are being taken to prevent aircraft violations. Although some intrusions have occurred, on missions STS 41-D and STS 51-C, no violations took place on missions STS 41-G and STS 51-A. The FAA is continuing its program to make pilots aware of the restricted KSC areas and resulting penalties. In addition, the FAA continues to impose disciplinary action on intrusion violators.

QUESTION M-4:

What is the current status of your attempts to resolve the reoccuring brake problems that have been experienced by the Orbiter?

ANSWER M-4:

Special instrumentation was added to Challenger to gather data during braking. Data obtained during braking following the STS 41-G missions is currently undergoing intensive review and analyses. Based on this data, it appears that main landing gear shimmy interacting with the brake anti-skid system may be involved in the brake damage problem. It is planned to gather additional data on subsequent flights of Challenger. The data from these flights will be used to help isolate the cause of the brake damage.

In addition to the use of flight data, a number of other steps are being taken as part of the brake corrective action program. These include a hydraulic system dampening study, development of a stiffer landing gear axle, flight vehicle landing gear/brake relative deflection measurements and dynamometer testing.

Following specific identification of the cause of the problem, a fix will be analyzed, tested and incorporated in the flight vehicle brake system.

QUESTION M-5:

In past weeks, there has been some debate within NASA about whether the softening of the rubber "screed" beneath some of the heat tiles of the Orbiter Challenger was due to repeated re-entry heating, a chemical reaction with the product used to waterproof the tiles, or both.

a. What is currently known about the source of the problem?

ANSWER M-5:

Following the STS flight of OV-099, several tiles were discovered to be loose. Upon closer inspection, it was determined that several thousand tiles over what is called "screed" could potentially be affected by a loss of bonding strength.

Screed is a type of Room Temperature Vulcanizer (RTV) that is used to smooth out irregularities in the aluminum skin. Intensive analysis determined that the re-waterproofing agent (6079) used between flights was acting on the screed and the RTV-560 bonding material in such a way as to cause the screed and RTV-560 to become soft. This softening then led to a loss of bonding strength.

While the exact chemical mechanism by which the DC 6079 causes the problem has not been finally determined (analysis is continuing) it is believed that the ammonia by product of the 6079 waterproofing agent or the swelling of the screed caused by the 6079 or a combination of the two are the leading contributors to the problem. Repeated applications of the 6079 are also a primary factor -- for OV-099, it had been re-waterproofed six times. Overall, approximately 4000 tiles were removed and replaced on OV-099.

QUESTION M-5b:

What is the likelihood that another Orbiter will be affected by this problem?

ANSWER M-5b:

Screed is used on all vehicles. OV-099 and OV-102 have more screed than OV-103 and OV-104.

OV-102 has been examined closely and no evidence of a similar degradation was found. However, this vehicle has been re-waterproofed with 6079 twice and the onset of the problem is believed to occur with approximately six applications. OV-103 has been re-waterproofed once. OV-104 has factory waterproofing and, therefore, no degradation would exist. (Factory waterproofing is done on the tiles as part of the manufacturing.)

QUESTION M-5c:

What is the long-term solution to the problem?

ANSWER M-5c:

The long-term solution revolves around three approaches.

The first and most attractive solution, is to find an alternative re-waterproofing agent that does not act upon the screed or the RTV-560 materials. A search is underway, but it will be some time before the findings are complete.

A second, and less desirable, solution would be to find a substitute for the screed material. There would still be a significant impact as all tiles over the current screed would have to be removed and replaced in order to apply a new screed. Substantial costs and vehicle down times would result.

A third approach is to remove the screed from all vehicles. This also would be a significant impact as it, too, would require the removal of screed and a "tailoring" of the tiles affected in order to achieve the proper aerodynamic configuration. This would be time consuming and costly.

A new re-waterproofing agent is the most desirable solution with less cost and schedule impact.

QUESTION M-5d:

Would it be advisable to add a protective shelter to the launch pads that would be capable of keeping rain away from the Orbiter?

ANSWER M-5d:

A temporary "rain shield" has been constructed on the launch pad at KSC. In addition, a less effective but non-degrading re-waterproofing material is being used for the interim period. The planned long-term solution is a new re-waterproofing material, however, an improved and more permanent rain shield is also under active consideration.

QUESTION M-6a:

At the present time, to what extent are Orbiter repair and replacement parts requirements capable of being satisfied with available stocks of spare parts rather than through cannibalization of other Orbiters?

ANSWER M-6a:

The Orbiter fill rate averaged 87 percent the last three months of 1984, (KSC 79 percent + RI Downey 8 percent).

QUESTION M-6b:

When will the need for Orbiter cannibalization be totally eliminated?

ANSWER M-6b:

NASA's logistics spares policy for the STS is to procure Line Replaceable Units (LRU's) in direct support of turnaround that will provide a 90 percent level of support effectiveness by April 1986. Quantities procured for systems not in direct support of turnaround will provide an 85 percent level of support effectiveness in the same time frame. It would be prohibitively expensive to procure the number of LRU's that would be required to increase support effectiveness to approach 100 percent. For this reason, it is expected that there will always be some cannibalization in the STS program.

SPACE SHUTTLE MAIN ENGINE

QUESTION M-7:

What is the status of current efforts to improve the reliability of main engine components?

ANSWER M-7:

The current focus of the SSME Program is to improve hardware reliability and life limits at 109% in the high pressure pumps. This development effort is largely complete and the certification test program is the culmination of 1 1/2 years of R&D testing on the high pressure fuel and oxidizer turbopumps. The goal of the R&D program is to improve the life at 109%, from 2 to 3 flights up to 10 flights, on both pumps. The first of two certification cycles on 2 sets of high pressure pumps has been initiated with testing scheduled to be completed by October 1985.

QUESTION M-8:

When will these improvements be retrofitted into the current supply of operational engines?

ANSWER M-8:

The pump improvements will be retrofitted into the flight program early in 1986. The remaining operational engines will be retrofitted at scheduled maintenance intervals with the final retrofit scheduled for FY 87.

SOLID ROCKET BOOSTERS

QUESTION M-9:

What is the current status of the effort to develop a lightweight filament wound case for the solid rocket booster?

ANSWER M-9:

The development of the filament wound case is progressing quite successfully. The first of two FWC SRM development motors was static tested in October 1984. Performance of the motor (DM-6) was as predicted. The second development test motor (DM-7) is scheduled for test on or about May 9, 1985. The qualification motor case segments have been manufactured and delivered to Morton-Thiokol for loading. The test of the qualification motor (QM-5) is scheduled for August 1985. The dynamic loads hydrotest of the structural test article (STA) at MSFC is proceeding ahead of schedule with no significant problems. All eight flight segments have now been loaded with propellant. Deliveries of the flight segments to VAFB are scheduled between the end of May and first week of July 1985, in support of the first launch from VAFB in early 1986. The estimated payload increase from the lighter FWC case segments remains at 4600 pounds. A damage tolerance test segment and four of the eight case segments for the second flight have completed the case winding phase of the manufacturing process.

SOLID ROCKET MOTOR

QUESTION M-10:

In the past, there have been several instances where one or more of the three recovery parachutes for a solid rocket booster have not fully deployed. Have these problems been resolved?

ANSWER M-10:

Yes, the problems have been resolved. As a result of assessment efforts by an investigation board, modifications were made both to the frustum structure which houses the main parachute and to the packing procedures. The most probable cause of the failures were found to be contact of the parachute canopy with the frustum during deployment. The corrective actions taken consisted of providing foam material to smooth out the structure so that any sharp edges were removed. Since these mods were incorporated, there have not been any failure of chutes to deploy.

SAFETY

QUESTION M-11:

Please elaborate on the most recent report of the Aerospace Safety Advisory Panel relating to the Space Shuttle. Are you aware of any unresolved issues concerning the Space Shuttle?

ANSWER: M-11

The latest Aerospace Safety Advisory Panel (ASAP) report focused on three of NASA's areas of responsibility:

(1) The Space Transportation System (STS) operations and evolving program elements,

(2) Establishment of the Space Station program organization and issuance of Requests for Proposals to the Aerospace Industry, and

(3) NASA's aircraft operations, including research and development flight programs for two advanced "X-type" aircraft.

With regard to the Space Shuttle (the majority of the annual report), 9 areas of interest were covered in some detail. Several of these items are continuations and/or expansions of previously reported observations, i.e., STS launch processing and logistics, Space Shuttle Main Engines, Space Shuttle Solid Rocket Boosters (both steel and filament wound cases), Orbiter structural adequacy, and Shuttle/Centaur. New items of interest include: Extra Vehicular Activities (EVA) and Life Sciences, using Orbiter 102 in an R&D role, KSC and VAFB common STS operations, and Radioisotope Thermoelectric Generator (RTG) as a spacecraft power source.

There are no unresolved safety issues at this time that preclude the conduct of safe Space Shuttle missions. There are areas that require continuing oversight by appropriate organizations, such as the maintenance of product quality and suitability as the STS matures and the activities become "routine". This requires being alert (by both hands-on and management personnel) to the signs of complacency and taking steps to avoid such a condition. The upgrading of critical components will continue to assure higher reliability and minimize effects of obsolescence.

UPPER STAGES

QUESTION M-13:

What is the current status of the Shuttle/Centaur development program?

ANSWER M-13:

We have completed all major design reviews for Shuttle/Centaur G and G prime (PDR's, CDR's) in addition to completion of the Payload Phase 2 Safety Review. We have delivered to the launch facility the G prime avionics simulator, which is presently being used to verify the functional compatibility of the Centaur to the processing facility. These compatibility tests are going very well. At Sycamore Canyon, where we perform our structural/fluid development testing, we completed approximately half of our planned series of tests when we experienced a leak in our liquid hydrogen tank. We have analyzed this problem, and repair is expected to be complete by April 26. Upon repair of the tank, we will complete the remaining development tests that we had originally planned. Completion of all Sycamore Canyon tests is scheduled for late this summer. Relative to the status of the flight vehicles, we anticipate delivery of the first flight Centaur Integrated Support Structure (CISS) to the launch facility on June 25, followed by the first flight Centaur vehicle on August 13, 1985. The second CISS and flight vehicle delivery to the launch facility is scheduled for October 31, 1985.

Relative to cost, a cost overrun for the Shuttle Centaur G and G-Prime Development Program is anticipated to be $60-$70 million. The DOD share of this overrun is $19.9 million and NASA will fund the remainder.

QUESTION M-14:

What is the current status of the Inertial Upper Stage (IUS) program? Are you convinced that it is now ready for use to launch your Tracking and Data Relay Satellites?

ANSWER M-14:

Investigations by the Air Force, NASA, and industry team of the IUS-1 flight anomalies that occurred during the April 4, 1983, launch of TDRS-A have been completed. Of the fourteen anomalies experienced, only the control anomaly was considered to have contributed to the IUS failure. Structural and thermal design and processing changes have been made to the IUS solid propellant motor nozzles to prevent recurrence of the techroll seal (TRS) collapse that caused IUS-1 to go into an uncontrolled tumble during the launch of TDRS-A, while the causes of the other anomalies have been corrected by making electronic and software design changes. Four heavily instrumented second stage flight motors have been test fired to provide verification of the redesign. In addition, the IUS successfully launched a DOD payload on January 24, 1985, with no anomalies and would have launched TDRS-B in March of 1985 except for spacecraft problems. This has resulted in the TDRS-B launch being delayed and currently manifested for launch in January 1986. The IUS is considered ready to launch TDRS when required.

QUESTION M-15:

Do you believe that the nozzle failures that occurred on the PAM rocket motors while attempting to launch the PALAPA and WESTAR satellites are fully understood? Have the problems been fully resolved?

ANSWER M-15

After extensive investigation, the McDonnell Douglas/Morton Thiokol failure investigation team determined that the most probable cause of failure of the WESTAR and PALAPA missions was an undetected low density area in the solid rocket motor nozzles. Improved inspection techniques using computer aided topography were employed during the failure investigation and are now used to assess each nozzle exit cone against stringent acceptance criteria before flight. While additional engineering data are required to better understand the thermostructural behavior of the nozzle components, the new inspection techniques and acceptance criteria result in a high probability for successful missions using the currently flying motor design.

McDonnell Douglas and Morton Thiokol have also designed and qualified a new nozzle for the PAM STAR-48 motor. The new nozzle is made of carbon-phenolic materials instead of carbon-carbon and is expected to have higher margins of safety, higher production yields, and shorter manufacturing schedules. However, the new nozzle is heavier and results in a performance loss. Both nozzle types are being offered to STS PAM-D customers. NASA plans to deploy the heavier PAM-Ds at 190 n.m. through 1985 to help alleviate the performance loss.

NASA believes that the actions taken by the commercial PAM-D suppliers to be appropriate for assuring a high degree of mission success. NASA is continuing activities to better understand the thermostructural behavior of composite materials used in solid rocket motors and to establish a related data base of engineering knowledge applicable to all solid rocket motors.

QUESTION M-16

Please summarize the research efforts that NASA has underway to help resolve generic problems in solid rocket motor technology. What are your plans for the future?

ANSWER M-16

During early CY 1984, a NASA/DOD/Industry committee examined our Nation's ability to design, build, test, and use Solid Rocket Motors

(SRM's). The committee concluded that technological shortfalls existed, in particular, when composite materials are used in motor nozzles. The Solid Rocket Motor Integrity Program was initiated in August 1984.

The SRM Integrity Program consists of two phases, the first of which examines currently flying motors to increase customer confidence in U.S. launch systems and to reduce the risks to currently planned missions. This phase is well underway. Nozzle exit cone material properties are being examined, analytical tools are being improved, and a heavily instrumented nozzle was tested on December 20, 1984. This first phase of the program is expected to be completed in early 1986.

The second phase of the program is a three year effort with the objective of establishing an urgently needed engineering data base of knowledge. This phase will examine a broader range of materials, processes, related physics and chemistry, product acceptance techniques, thermostructural analyses, instrumentation, and testing. This program has been coordinated and formulated with DOD and industry participation; NASA anticipates continued active participation from these sources. Seven of the nine major tasks of this phase are expected to be on contract during the April/May 1985 time frame.

Definitive plans beyond the SRM Integrity Program are dependent upon the program findings.

SUPPORT FOR SPACE SCIENCE

QUESTION M-17:

As excess capacity becomes available in the Space Shuttle manifest, to what extent will this excess capacity be used to support additional space science missions?

ANSWER M-17:

If excess capacity becomes available after accommodation of all primary payloads, including DOD, commercial, and NASA payloads, this excess can certainly be made available to any additional NASA science payloads. Any additional major NASA flight requirements would have to be reviewed, and funding prioritized, as part of the normal budget process. Major NASA science payloads normally require substantial budget obligations, long development leadtimes, and significant Space Shuttle integration effort. Minor payloads could be added to better utilize existing capability in manifested flights to the extent they are compatible with the major payloads already on the flight. The Hitchhiker system is specifically designed to accommodate small payloads when excess capacity becomes available late in the launch processing flow.

QUESTION M-18:

Please explain the criteria that are used to establish the relative priority between military, commercial, planetary, and space science payloads when the manifest must be rearranged to accommodate a launch delay?

ANSWER M-18:

In the event that the manifest must be rearranged to accommodate a launch delay, the criteria used to establish relative priority are as follows: (1) priority DOD missions with national security implications; (2) planetary missions or other high priority missions with a critical launch window (i.e., Halley's comet, etc.,); (3) reimbursable commercial missions with contractually established schedules; (4) NASA primary science missions with flexible launch windows; and (5) secondary payloads (e.g., mid- deck, Hitchhiker, Getaway Special payloads, student experiments).

BUDGET STRUCTURE

QUESTION M-19:

Last year NASA made a major change in the organization of its budget, separating R&D programs from "operational" programs. In this year's budget, however, we noticed that the funding for "operational" Spacelab mission, and the purchase of "operational" upper stages are listed in the R&D rather than the operational section of the plan. Why is this so?

ANSWER M-19:

The structure of the FY 1986 Budget for OSF Programs is identical to that used for the FY 1985 Budget. The activities in Upper Stages and Spacelab Operations is directly associated with R&D programs. For example, the Upper Stages Operations for Centaur is for procurement of stages to be used for NASA planetary missions; Spacelab Operations is for processing and integrating hardware supporting only scientific missions. For these reasons, it was felt appropriate to include the funding of these activities within the R&D appropriation rather than in the Space Flight, Control and Data Communications appropriation which provides a generic support (Shuttle launch) to all categories of payloads.

Secondly, this budget structure isolated the cost of operating the Shuttle into one specific budget line thereby providing improved visibility and increased management control of this important activity.

SPACE SHUTTTLE MAIN ENGINE COMPONENT IMPROVEMENTS

QUESTION M-20:

Last year, NASA initiated a program with two rocket engine development companies to design improved components for the existing Space Shuttle Main Engine. We have been led to believe that one contractor is designing improved components that could be retrofitted into the existing inventory of Space Shuttle Main Engines while the second is proposing the development of what is essentially a new engine.

a. Is this true?

ANSWER M-20:

a. Both rocket engine development companies have proposed improved component designs that can be retofitted into the current SSME design, however, one of the companies has proposed more extensive component design changes which would require changes to the current engine configuration.

QUESTION M-20b:

b. How much does the government have invested in the Space Shuttle Main Engine?...both in terms of R&D and production expenses?

ANSWER M-20b:

b. Through FY 1984, the total development and production funding totals approximately $2.6 billion.

QUESTION M-20c:

c. It seems to me to be reasonable to make improvements in individual components that can be retrofitted into existing engines in order to extend or improve their operating life, but given the large investments that have been made in the existing engine hardware, what would be the rationale for developing what is essentially a new engine?

ANSWER M-20c:

c. A new engine is not being developed, however, new individual improved components for the existing engine are in a study phase of development. The objective is to retrofit the new components into the existing engine system and extend and improve operating life thus saving costs and increasing reliability over the long term of the program. Different design approaches by the two contractors to resolve current engine component problems should not be perceived as a "new engine" design. There is currently no rationale for developing a "new engine" for the Shuttle.

Mr. **Nelson**. OK, thank you very much, Mr. Moore.

Give me your opinion, will the space shuttle be the primary or principal U.S. launch vehicle in the next 20 years?

Mr. **Moore**. Well, as you know it's hard to put your crystal ball out here and to say conclusively what the situation would be, but let me say initially that other systems take a long time to develop and on the order of 10 to 12 years to bring new launch capability systems into being. The shuttle took approximately 10 years, from 1972, where we initially got development, until 1981, and I would have to say that, yes, I am convinced that the space shuttle will be the primary system in the United States for launches through the next—through this century, at least, and maybe into the early phases of the next century.

Mr. **Nelson**. All right. Given that response, what is your opinion that there would be a likelihood of either increased launch traffic demand or, Lord forbid, an accident, which would result in the need of a fifth orbiter before the year 2000?

Mr. **Moore**. Well, market demand is something that is hard to predict, but let me give you my, at least assessment of the market demand. We have seen some decline in commercial market demand, I think, over the past year or two. I think we were more optimistic over the past couple of years about commercial traffic, commercial communications satellite traffic, than I am today. I'd say the market looks to me, in the next 5 years, to maybe be saturated on the order of 15 to 18 to 20 communication satellites per year, and with that kind of a market projection, as well as the NASA traffic that we have planned, I think the program we've got laid out for the shuttle is adequate for four orbiters to cover that traffic demand at least in the next 5 or so years.

Beyond that I think it's hard to predict. I think there are a number of things that can open up larger traffic demands. I think some of these commercialization ventures could have very, very important impacts in terms of demanding more flights. There could be more breakthroughs in communication satellites or other commercial endeavors, which I think could increase demands. We could also see some increased demand potentially from SDI, the strategic defense initiative and so forth. We could also see it from potentially a space station, but right now I would say that our market projections this year are a little more pessimistic than they were last year and I think we're seeing somewhat of a saturation in this market at this point in time. And I would say, given our fleet of orbiters that we've got now, we can meet that particular traffic demand, at least in the next 5 or so years.

However, if you bring up the question of accident, and God forbid any accident occurring in this thing, that's very hard to predict. It takes a fair amount of time to bring another orbiter on line and so forth and I would certainly hope that that never occurs and we never have to face that situation, but if something like that were to happen it would take us awhile to get another replacement vehicle in place to cover that gap.

Mr. **Nelson**. What you're saying is that you need four orbiters and if you lost one, temporarily or permanently you'd need another.

Mr. **Moore**. That's correct.

Mr. NELSON. OK now, the budget that you've come forth with delays, again, the fifth orbiter decision, and as I stated to Mr. Beggs, I think he's done a masterful job, given the constraints that he has from OMB, and I understand that operation and this isn't to dump on David Stockman at all. David Stockman has a—one of the toughest jobs in Government and I empathize, as somebody who understands the budget and has been on the budget committee for the last 6 years, it's one of the toughest jobs in Government is what he has. But, the fact is, as it has come out in the constraints upon you, you can't go on with the fifth orbiter, so there are going to be delays.

Now, my question to you is, do such delays increase the ultimate constant dollar cost of the vehicle or are the costs going to rise merely as the same rate of inflation?

Mr. MOORE. Well, let me comment on what our program does.

Mr. NELSON. Is my question clear?

Mr. MOORE. Yes, I understand your question, I believe, and I'll get to it in just a second. Let me comment, first of all, Mr. Chairman, what our program includes. Our program, we believe, includes adequate funding for continuing production of spares, continuing the structural spares program to at least put us in a position, through fiscal year 1986, of maintaining a viable base for initiating an orbiter beyond fiscal year 1986. The longer you delay, in terms of constant year dollars, there's certainly an inefficiency that's going to be put into the program. It's just like waiting where the lines are down, you've got to probably do some retraining of people, although you can pull some of the people back into the program, you've got, as I said, retraining. It's just like kind of stretching a program out. You can stretch a program out for a very long period of time and you wind up not doing all the jobs you should do at the time in order to achieve the greatest efficiency.

So, I think there will be some small, I think it will probably be a reasonably small increase, increase in the orbiter cost, due to the inefficiency. On the order of a few percent. And I think on top of that you could add in the inflation costs and so forth that might be attendance in those particular years to see the cost.

Mr. NELSON. OK——

Mr. MOORE. Beyond 1987, if you start up an orbiter it's going to, I think, be probably more costly unless you keep some production base going that you can build from.

Mr. NELSON. OK, in light of that answer then, my question, before I share with my colleagues here, and I'll finish the question up after they've had a chance to—would be this, what is your opinion if it would be possible to build a fifth orbiter slowly over the next seven or eight years and would that interfere with other NASA program funding requirements?

Mr. MOORE. Well, it certainly would take more funding in those out years than is currently in our program. We do not have any funding, beyond the fiscal year 1986, for continued orbiter production, aside from spare support and so forth to the program, and it's an add-on to our run-out budget. And so, to the extent that we have to increase the run-out budget in the Agency it would be competing with other activities that would be competing for wages and so forth available for new start, so yes, I think it could potentially be in competition with other things in the NASA budget. That is not included in the run-out of the program now.

Mr. NELSON. Is it possible to stretch that out over say, 7 or 8 years, where you don't have a critical competition for those dollars?

Mr. MOORE. That's not clear. I think there's always competition for dollars, and as you know, and as Mr. Beggs stated, the budget this year does not include any new space science starts and there's always competition for new initiatives in the scientific arena as well, so I kind of doubt that you could include funding in the budget without some competition, as far as the run-out of the NASA budget is concerned.

Mr. NELSON. OK, Ms. Meyers?

Ms. MEYERS. No questions.

Mr. NELSON. Mr. Volkmer?

Mr. VOLKMER. Thank you very much, Mr. Chairman. Mr. Moore, it appears that the major initiative will be the OMV for this fiscal year, is that correct?

Mr. MOORE. Yes, sir, for fiscal 1986 the OMV is the major new initiative in the Office of Space Flight's budget request.

Mr. VOLKMER. And how much did we spend on the OMV, either in design or anything else, in fiscal year 1984 and 1985?

Mr. MOORE. In total in fiscal year 1984 and 1985 we spent approximately $5 million or we will have spent approximately $5 million. We've got three phase B contracts underway right now with LTV, Martin Marietta and TRW and those contracts are approximately worth $1½ million. And in 1984 we also did some, what we call phase A studies, conceptual studies and we spent on the order of a couple of hundred thousand dollars on those studies.

Mr. VOLKMER. Now, this $25 million for 1986, is that still phase B or are we going——

Mr. MOORE. No, sir. That is funding for initiating development, so that will go into what we call our phase C/D effort, which is the start of the development phase of the program, leading to the first unit delivery and flight by 1990.

Mr. VOLKMER. OK, that, and I don't remember, maybe Terry could tell me or somebody else, staff could tell me, is that going to be in time to boost the space telescope?

Mr. MOORE. We have been looking at that——

Mr. VOLKMER. Is that too low, we're going to put it up with the shuttle the first time around.

Mr. MOORE. Oh, we're going to put the space telescope up with the shuttle as high as we possibly can and we're going to get the maximum performance to put it up as high as we can when we launch it in the summer of 1986. I think it's very hard to predict what the Sun activity is going to be. You know these satellites are a function of the solar activity and the more solar activity you have you can get higher drives and so forth, and therefore, you get orbit changes. However, I think we're all confident that the first flight of the OMV will be in time to provide any boost services required by the space telescope, at least that's what we're working on right now. But again, it's unpredictable. I can't predict the solar activity.

Mr. VOLKMER. OK, of course the OMV will be taken up on a shuttle.

Mr. MOORE. Yes, sir.

Mr. VOLKMER. On the solid rocket boosters, as I understand it we're now looking at a possible competition on those SRB's, is that correct?

Mr. MOORE. What we have done, Mr. Volkmer, is to look at the possibility of implementing what we call a second source. And a second source would be where you have two suppliers of the solid rocket motor. We have only advertised in Commerce Business Daily to get expressions of interest from industry as to whether or not they would be interested in undertaking such a second source. That advertisement solicited interest and we received interest from four companies. We are evaluating those responses at the present time and we will make a decision sometime in the spring as to whether or not it's feasible to pursue this any further.

We are quite happy with the performance of Morton Thiokol and the SRM's. We are trying to get as much efficiency as we can in the program and we will only undertake a second source in the event it's economically the right thing to do and does not impose any kind of constraints on the safety or reliability of the shuttle. We are only in an exploratory phase at this point in time and have not made any decision to implement a second source.

It further takes a lot of time to qualify a second source. There is facility investment requirements and things of this nature to get a second manufacturer capable of producing SRM's and so these are all factors that we want to evaluate as far as the solicitation that was just closed not too long ago.

Mr. VOLKMER. Well, as I view it this is the—part of the whole shuttle operation that we use most of and——

Mr. MOORE. Yes, sir, we use two of them on every flight.

Mr. VOLKMER. And if we ever get to 24 a year operations we possibly could get into a bind, couldn't we?

Mr. MOORE. Possibly, yes sir, possibly. You could also look at some shuttle derived launch vehicles. If some of those types of concepts might come into being where we require an additional solid rocket motors, you could talk about a significant quantity of the solid rocket motors. So, we're exploring that, but I think our decision is going to have to wait, obviously, until we've gone through the evaluation of what industry is willing to propose in this area.

Mr. VOLKMER. OK, but you have had some interest in it, so there is——

Mr. MOORE. We have had four expressions of interest, yes, sir.

Mr. VOLKMER. Now, on the heat tiles on the Challenger, are we going to be looking at the same thing on the other orbiters after a couple more flights?

Mr. MOORE. We don't think so. We think that the screed problem, the reversion problem we experienced on Challenger, from its flight back in October, we discovered soft screed was due to a factor of the number of times we had used the water-proofing-injection scheme. On Challenger we had injected the orbiter, the tiles on the orbiter, six times. And on the other orbiters, obviously Atlantis has got factory water proofing on it. I believe, 102, has only been injected with it once or twice at most, which is Columbia and we have tested Columbia, by the way, out in the Palmdale facility, where we undergo a mods and it looks good. All the tests have come out very well on it. And Discovery has only been injected, I believe, once, with the water-proofing material that we had been using.

We have suspended using that material and have gone back to a technique we used on the earlier flights, called Scotchgard, and that will be used in the near term on our birds, while we fully understand this chemical problem we have with respect to the reversion of the screed. We think that chemical problem is caused, not only by the amount and the number of times we inject the water-proofing solution into the screed material, but it's also a function of temperature and it's also a function of some of the chemicals in the so-called water-proofing material that we're using, and that these chemicals combine to react, after period of time and after a certain number of injections, to cause the material that we use to fur the surface of the orbiter out, called screed, to get soft and basically revert from a hard state back to a soft state.

I can't guarantee we will not see this, however, we are taking every precaution we can to check the orbiters. To date, we have not seen any additional evidence of it and I feel relatively comfortable that we are not going to see any more of this downstream, from this particular problem.

In the interim timeframe we have constructed a rain-shift—not rain-shift, I should say a rain shield at the Kennedy Space Center, to protect the orbiter from water the best we can, prior to its launches. I view this as being something that we will use in the very near term while we continue our concerted analysis to find the full solution to the problem, as well as potentially find, which hopefully we're looking for, is an alternate water-proofing agent. There are several solutions to the problem, looking for a new water-proofing agent, you can change the screed on the orbiters. The latter is certainly a very time-consuming thing. And, we're looking at alternate water-proofing solutions and we've got quite an extensive laboratory analysis underway to give us data on that.

I reviewed it back in December and have another comprehensive review planned in the March timeframe on that. So, I think we've got a capability to get by in the interim timeframe and we're working very hard on a more permanent solution to this particular problem.

Mr. NELSON. OK, Mr. Walker, did you want to share with us your statement or—we've already entered it in the record.

Mr. WALKER. I'd ask unanimous consent that it be entered in the record.

Mr. NELSON. It's already been.

Mr. WALKER. That's all I need, Mr. Chairman, thank you.

Mr. NELSON. OK, would you like to ask any questions or would you like me to call on Mr. Smith?

Mr. WALKER. I have a few questions. Thank you, Mr. Chairman. I understand that you have discussed a little bit the fifth orbiter situation and indicated that you do not see, within the next 5 years, the need for a fifth orbiter, but that at some point, once the space station is in place, that in fact we might have such a need. Do I understand that your testimony is that in fact we could meet that need at that time with the spare parts program that is presently underway?

Mr. **Moore**. Let me amplify a little bit on my previous answer and then I want to make sure I understand your question, Mr. Walker.

As I stated earlier, based on the demands that we've assessed during this past budget formulation cycle, we see no changes in the demands from where we were last year as opposed to requiring a fifth orbiter. In fact I'm a little more pessimistic about the marketplace this year than I was last year in terms of the requirements, so in the next 5 or so years I think our four orbiter fleet, three launch pads, three MLP's [mobile launch platforms], are more than adequate to meet the 24 flight per year rate capability that we've identified and plan to fly.

If you look beyond that there are some things that we don't know at this point in time that may—say our demand model is going up higher and it's awfully hard to put a crystal ball out and say that we're going to see enormous growth in commercialization of space and therefore, we're going to see a lot of launches in that area. I think space station requirements beyond the mid-90's are something that we're going to be working on and so forth. How often maybe the commercial people want to be services in the space station and so forth. We're talking about things like leasecraft and other things that might be serving electrophoresis platforms in space, these could demand a lot of launches, and I also mentioned, we're not sure what the full DOD requirements are going to be as far as the space shuttle is concerned, in the long term. So, there are scenarios that one can formulate that can say, yes, you will need a fifth orbiter sometime downstream in the nineties to meet those demands, if they all materialize.

Mr. **Walker**. Well, my concern is that if we reach that point that we will not have the capacity to be able to fulfill that need at that point and will have to go into production either with a new generation of shuttle or will have to reform a team in order to build that fifth shuttle, which will make it extremely uneconomic at that particular time. What is your analysis of that?

Mr. **Moore**. Let me make two comments on that. First of all I think we will be looking in the coming year and years at maybe shuttle 2, some kind of a derivative shuttle vehicle, but that's a long-term thing——

Mr. **Walker**. Do you have a timeframe for that?

Mr. **Moore**. I think it's at least the year 2000 prior to seeing something like that happen. It takes 10 to 12 years to bring on new systems of the kind of complexities that we've seen, it would be my guess. So, in terms of new capabilities and new shuttles I think it's the end of the century in terms of what we're looking at, so, I think we're going to fly the space shuttle through this century and be the primary launch system in the United States and maybe even beyond that.

Now, if I look at the other point that you mentioned about the——

Mr. **Walker**. If I could just interrupt you there. Some projections I have seen recently indicate that the minimal budget, minimal commercial budget, by the year 2000 is somewhere in the vicinity of $60 billion. Now, do you contend that a four orbiter fleet could really service a $60 billion space-based economy?

Mr. MOORE. By the end of the century?

Mr. WALKER. By the end of the century.

Mr. MOORE. Well, if the budget materializes to that level, and it all depends upon what launch frequencies the commercial sectors need to service their particular systems, I can't sit here and say that four orbiters are going to meet that. I can sit here and tell you two things, one is, we believe the four orbiter fleet is adequate to meet the 24 flight rate per year that we have in the plan. Point No. 2 is, our budget is continuous production of orbiter spares and orbiter production capability through the fiscal 1986 timeframe. And we believe that the production capability is maintained through fiscal year 1986 with minimal loss of critical skills. Beyond that timeframe you're beginning to roll down a hill and the steepness of that cliff gets steeper the longer you wait. And so, if we can project traffic accurately in the mid-1990's and so forth and the models demand greater than a 24 flight rate per year we have, then yes, we're going to need additional orbiter capability.

Mr. WALKER. And the chances are that we probably can't, because until you put the space station on line and begin to get an understanding of what the commercial needs are, the chances of projecting that become very, very difficult and so what your testimony really is is that we have a chance that at that point we are going to have a significant commercial need, that we probably can't produce a vehicle that can meet those needs until the year 2000 and so we find ourselves in—are going to find ourselves in a very frustrating period, perhaps, in the mid-1990's.

Mr. MOORE. Well, we've estimated also, Mr. Walker, that we think with a start we can produce an orbiter, depending upon the funding, from anywhere from 5 to 6 years. Five or 6 years is a timeframe or 4 to 6 years, as a matter of fact, with the base we build up. With the help of the Congress——

Mr. WALKER. A new generation of orbiters you're talking about?

Mr. MOORE. No, I'm talking about another shuttle orbiter, a fifth orbiter for example.

Mr. WALKER. But, wouldn't that be a tremendous cost if you had to put that whole team back together again?

Mr. MOORE. Not if the decision is made in the near term. I'm saying if you make that decision in the real long term the longer you wait the longer you wait to make that decision it is going to be more costly to bring up the team in order to do this.

Mr. WALKER. Yes, and that really was my concern. Let me follow up then, what has been done in terms of reaching out to other sectors in order to find that financing with some immediacy? For example, I suggested last year that we ought to make some very serious efforts of looking at the international community and finding out that the international community that want so much to cooperate with space station, whether or not they would be willing to put significant funding into building the fifth orbiter capacity, so that they would have their own capacity to reach that space station at the point their participation reaches fruition. Has that been seriously explored?

Mr. Moore. I think there has been some—clearly been some dialog. I'm not sure how to define your word "seriously"; there's certainly been some dialog, but the majority of that dialog during the past year has been focused on international participation in the space station.

Mr. Walker. I understand, but——

Mr. Moore. And with the European partners in the space station. The other things we're seeing is that a lot of countries, like Japan, with their launch vehicles, are interested in putting their own launch systems together; Chinese have their own launch capability they're working on. Obviously, the Arian has its own capability, and I believe the EASA Council just approved additional funding for future Arian development, and the British are looking at their own types of shuttle vehicles. So, the dialog has not been very positive, to my knowledge, Mr. Walker, in terms of encouraging—getting encouragement from the international partners, as far as buying a fifth orbiter.

Mr. Walker. But, if they want launch capacity wouldn't it make sense for them to buy a launch capacity that's already proving itself, if in fact we could offer them the kind of incentives to go ahead and do that. One of my concerns is that what we may be doing is not offering them the kind of incentives that are necessary in order to get them to buy that fifth orbiter. That what we're doing is strapping on to them all of our defense requirements and all of the various things that would apply to our other four orbiter fleet. I mean, are we really reaching out and saying that you, in fact, can purchase your own lift capability by purchasing the fifth orbiter or are we tying down so many conditions, as I'm concerned that we did with the private entrepreneurs that came in. That we told the private entrepreneurs that, yes, we'd love to have you explore this, but here are the conditions under which you've got to think about it and the private entrepreneurs simply couldn't find a way that they could survive economically under the conditions that we imposed upon them.

Mr. Moore. I understand your concern. Let me suggest to you that we will go back and provide you information on what specifically has transpired relative to the international interactions, but may I also remind you, to my recollection most of that interaction has been relative to space station participation and the old partnership and the fact that a lot of the international countries have a desire for their own launch system, so they will be launch independent and so forth.

Mr. Walker. But, you understand my point——

Mr. Moore. Yes, sir.

Mr. Walker [continuing]. That the space station really becomes only partly useful to a country that participates in space station but doesn't have a compatible transportation system to get there. That if in fact they commit theirselves to space station and don't have a shuttle capacity or something very similar, that the space station is not as useful to them and it seems to me that if you can convince them that they ought to participate in space station, that you could also convince them that buying a fifth orbiter or a sixth or a seventh might, in fact, be a very good investment if they intend to use the space station adequately. And my concern is that we have not properly presented that to them in a way that assures them that they would buy a complete capacity on their own and not buy into simply the capacity that we're developing.

Mr. **Moore**. I understand your concern and let me provide you what data I can on that, sir.

Mr. **Walker**. OK, thank you.

Mr. **Nelson**. Well, I appreciate the round of questioning. If anybody has any additional questions just tune in here. I have a number of others.

Following up on Mr. Walker's line of questioning, what extent would critical production skills be lost during this coming fiscal year, fiscal year 1986, under what you propose in this budget?

Mr. **Moore**. Well, I think that we obviously will lose a few critical skills, but we spent the past year in our logistics program, as well as the structural spares program, trying to insure that we have maintained, to the maximum extent possible, those critical skills required to start up a production line.

Mr. **Nelson**. And you do——

Mr. **Moore**. And I think, Mr. Chairman, the loss will be relatively small.

Mr. **Nelson**. OK.

Mr. **Moore**. I'm hard pressed to give you a quantitative number, but I think it's relatively small.

Mr. **Nelson**. You did a good job there and we came along and was it last year that we added $40 million?

Mr. **Moore**. Yes, sir.

Mr. **Nelson**. OK, then on that basis, what kind of funding increase for fiscal year 1986 would you have to add to the structural spares in order to keep those skills from being lost?

Mr. **Moore**. I would like to provide you an answer for the record for that, if I could, Mr. Chairman, I don't have that answer handy with me today.

[The information follows:]

We feel the current funding levels for the structural spares and logistics programs are adequate to maintain the skill levels through FY 1986 which are required to maintain the option to begin building a fifth Orbiter. Any requirements above these approved funding levels are seen to be small, and adjustments can probably be made to compensate for them without requesting additional funding.

Mr. **Nelson**. OK, all right, let me ask you about the Centaur.

Mr. **Moore**. Yes, sir.

Mr. **Nelson**. Rumor is that there is going to be a projected overrun, quite large, is there?

Mr. **Moore**. Yes, sir. As I mentioned in my opening statement here, we have seen some estimates back from the contractor to Lewis Research Center, which indicates that our estimates are going to increase.

Mr. **Nelson**. By how much?

Mr. **Moore**. We're not sure exactly what the increase is going to be.

Mr. **Nelson**. Well, do you have a range?

Mr. **Moore**. I would say on the order of several—a couple of tens of millions of dollars, $30 million, $40 million, somewhere in that ballpark. We are working that now with the Lewis Research

Center, General Dynamics, and the Air Force to try to come up with what the real issue and the real cost estimate increase is.

Mr. NELSON. All right, why is this just coming to light now?

Mr. MOORE. We had been over, I guess, our manpower plan, in terms of trying to make up a schedule on the Centaur Program since about last December and at that time we sent a team to go and look at where we were in the Centaur Program relative to cost, completion, and so forth. That team spent about 2 months evaluating and basically doing a grassroots cost estimate of what would be the real requirements to complete the Centaur Program. That analysis was just done at the very last part of January, early February and we are receiving the benefit of that analysis at this point in time.

Mr. NELSON. Was that analysis done too late?

Mr. MOORE. I don't think the analysis was done too late, Mr. Nelson, I think that we saw that we were over a little bit in manpower in terms of—in terms of our plan for testing, but we were seeing our testing progress increase and I think we've just simply seen an underestimate of the amount of materials cost, the amount of labor required to complete all the testing and the manufacturing and production of these four vehicles. I would not say it was done too late. I would have obviously loved to have seen it done much earlier than that, but until we saw that the manpower was running substantially over plan for some period of time, we did not have a real good signal of that and Lewis and General Dynamics went over a very comprehensive analysis over the past couple of months.

I believe, however, we should be able to resolve this within our program flexibility.

Mr. NELSON. And what kind of program control are you going to have, so that this doesn't happen?

Mr. MOORE. What we are doing and what we will do with the Lewis Research Center is that we will continue to get our monthly cost report. We will continue to even look at them on a much more frequent basis and continue to have assessment reviews much more frequently than we've had in the past as we get closer to the launch schedule of these two things.

Mr. Weeks was just at Lewis Research Center talking to the Lewis people. Mike, would you like to elaborate a little bit on this?

Mr. WEEKS. Well, Mr. Nelson, I think one thing that you should know is that we've been underway 2½ years on the program and there is not an overrun today. It is a projected overrun that's got us seriously examining this whole problem. And of course I think we're kind of proud of the fact that we started on July 18, 1982, with what I consider a very major development of a major new upper stage, of which this total program of nonrecurring and recurring for four launches is $800 million. And, we have gone 2½ years without this problem coming up, but we are on a 7-day week, three shifts, out at Sycamore Canyon, doing the testing, as Jesse showed you of the first article. And, GD and the various subs and other associates, Pratt and Whitney and Teledyne and Minneapolis Honeywell are doing a fine job of making two launches, which we have to pull off in May 1986, which is just, I believe, 46 months from the day we started. And, for a major launch vehicle that's a significantly difficult accomplishment and yes, as Jesse has said, there are some cost problems and we're having to work a 7-day workweek out at Sycamore Canyon, but we're going to make those two launches in that very narrow window in early 1986.

Mr. **Nelson**. But NASA is the Agency where the impossible dream is accomplished every day. [Laughter.]

Mr. **Weeks**. We do have to work a lot harder sometimes to make that so.

Mr. **Moore**. On other programs, right.

Mr. **Nelson**. Are we going to see any more of these little surprises coming around on the Centaur?

Mr. **Weeks**. One of the things we're doing, as Jesse spoke, is we're trying to be very careful in this review that Lewis is doing and GD is doing, to be as careful as we can to be sure that this major cost review at the 2½-year point is not—does not have to be repeated prior to—certainly prior to May 15, 1986, and of course the two more short Centaurs, as Jesse told you, that have to be launched for the Air Force. So, this is four launches of an extremely major national capability.

Mr. **Nelson**. You mentioned, Mr. Moore, that you could do this within your available funds.

Mr. **Moore**. We think so, yes, sir.

Mr. **Nelson**. You're going to reprogram from someplace——

Mr. **Moore**. We have contingency, planned contingency in the Centaur Program that we will look at and clearly apply to solve this kind of a problem. That is the purpose——

Mr. **Nelson**. $40 million worth?

Mr. **Moore**. That is the purpose of putting contingency. I don't know, Mack Steel, do you have the amount of contingency we have in the Centaur Program?

Mr. **Steel**. I don't have it handy. The $40 million problem, though, is going to be—if it is $40 million, is going to be spread over more than just 1 year.

Mr. **Nelson**. Right.

Mr. **Steel**. And as Jesse indicated we just don't know how confident the $40 million is of being the right number right now.

Mr. **Moore**. I think we've got close to that level of contingency in the program. There's also some contingency in the Air Force side of this activity as well and we're going to work very closely with Lewis, the Air Force, General Dynamics, to try to get a complete resolution to this problem.

Mr. **Nelson**. You mean you're going to get some money from the Air Force?

Mr. **Moore**. The Air Force has been providing us funding, as you know, Mr. Chairman, on the Centaur. They have a commitment in the development program, as I understand it, of $50 million and are paying their share of the development activities for the G-vehicle, which is a shorter vehicle, and we're going to be working with these elements in order to get this problem under control. As I said, we do not know the exact magnitude of this. We have a review team in place now to do it, I am confident we can solve this within our program flexibility.

Mr. NELSON. OK; awhile ago you were telling Mr. Volkmer that you were looking at a protective shelter to protect the orbiter from rain. Were you talking about a temporary or permanent facility?

Mr. MOORE. No, sir, I'm talking about a temporary facility that we have already constructed. It is in place at the cape and it was, in fact, up during the flight we had in January. This is a temporary shield that minimizes the orbiter tile surfaces from water exposure.

Mr. NELSON. OK.

Mr. MOORE. This is put up once the vehicle gets to the launch pad. It's kind of wrapped around the vehicle and it's taken down about 12 hours prior to launch, at the time we start to load the cryogenic fuels.

Mr. VOLKMER. Would the gentleman yield?

Mr. NELSON. Certainly.

Mr. VOLKMER. I'd like to get into something that's similar to that. Right now we have two orbiter processing facilities——

Mr. MOORE. Yes, sir.

Mr. VOLKMER [continuing]. At Kennedy, right?

Mr. MOORE. Yes, sir.

Mr. VOLKMER. And I guess by September we're going to have three birds down there.

Mr. MOORE. Yes, sir.

Mr. VOLKMER. Where are we going to park the third one?

Mr. MOORE. Well, one of the birds is going to be at Vandenberg——

Mr. VOLKMER. But, we've got four.

Mr. MOORE. We've got four orbiters. We've got two orbiter processing bays at the cape and we've got one orbiter processing facility our at Vandenberg.

Mr. VOLKMER. All right.

Mr. MOORE. What we will have to do when we have three orbiters in flow is to have one in the VAB in stacking process or else out on the MLP on the pad, while the other two are in flow down at the cape. So, we may have to use the VAB as temporary storage and as you know, Mr.——

Mr. VOLKMER. Are you telling me that, somewhere in between time, we're always going to have one being refurbished?

Mr. MOORE [continuing]. No, well we're going to have—after each of the flights they go through a certain amount of checkout and so forth and reconfiguration ready for cargo. I do not intend to see our orbiters continue to be mod—upgraded as a long term period of time.

The other point I wanted to make is that we have requested, in the fiscal year 1986 budget, a C of F item, construction of facilities item, for the third bay at Kennedy Space Center. This would be initiated in fiscal year 1986 and be online, ready to house an orbiter, by the first part of 1987.

Mr. VOLKMER. But by October of this year Atlantis is finished——

Mr. MOORE. Yes, sir.

Mr. VOLKMER [continuing]. Columbia is finished with its modifications.

Mr. MOORE. Yes, sir.

Mr. VOLKMER. Discovery is ready to go.

Mr. MOORE. Yes, sir.

Mr. VOLKMER. It's still going and Challenger is going.

Mr. MOORE. Yes, sir.

Mr. VOLKMER. Now, where are they all?

Mr. MOORE. OK, Discovery, in September, will go to Vandenberg.

Mr. VOLKMER. All right.

Mr. MOORE. And it will go into the Vandenberg processing facility for its initial launch out of Vandenberg in—no earlier than January 29, 1986.

Mr. VOLKMER. All right.

Mr. MOORE. Both Challenger and Atlantis will be at the cape and 102, Columbia, will have been completed, its mods will have been completed out at Palmdale and will be back in delivery—in the fleet by July, so in September we'll have three orbiters at the cape. Two orbiters will be in the orbiter processing facility, at any given time and another orbiter will either be in the vertical assembly building, on the mobile launch pad, on the launch pad or either in orbit. And so, we will rotate the orbiters through this—using this particular method. We've got a flight a month, so at any given time we will either be in the VAB doing final stacking on orbit and use that process to get us through until we have the third orbiter bay at the cape. And if necessary we will, reluctantly, use the vertical assembly building for storage, if we get into that problem.

Mr. VOLKMER. You would be able to use it for storage then?

Mr. MOORE. Yes, sir. We don't like to do it and we would not plan on doing it, but if necessary we will do that.

Mr. VOLKMER. That won't impinge on your processing time?

Mr. MOORE. No, sir. We would plan to store the orbiter out of the way.

Mr. NELSON. All right, in those budget items for fiscal year 1986 that you just talked about. One was a orbiter modification and refurbishment facility.

Mr. MOORE. That's it.

Mr. NELSON. Is that what you're talking about——

Mr. MOORE. Yes, sir.

Mr. NELSON [continuing]. An additional one in one of the bays in the VAB?

Mr. MOORE. No, sir. This would be on a construction that would be close to the current orbiter processing facility——

Mr. NELSON. So, it would be a second orbiter processing facility?

Mr. MOORE. It would be actually a third bay. We've got two bays——

Mr. NELSON. Third bay of——

Mr. MOORE [continuing]. At the current OPF at the cape. We would add another bay and this would be the money for the facility of building that facility at the cape and it would give us the capability of housing an orbiter next to the other two OPF bays that we have there.

Mr. NELSON. OK, now what about—you ask for something for a thermal protection system facility, TPS.

Mr. MOORE. Yes, we would plan to put a TPS facility at the cape so we can do the TPS necessary on these birds after each of the flights. We wind up having to refurb or replace some 10's of tiles after each of the flights and we would plan on having that capability at the cape in order to minimize the turnaround time with the orbiters.

Mr. NELSON. And that is in a facility separate and apart from the OPF?

Mr. MOORE. Yes, sir.

Mack, do you want to elaborate on that a little bit.

Mr. NELSON. When are you supposed to come with that one? When do you start building?

Mr. STEEL. That project is in the fiscal year 1986 budget as well for about $3½ million.

Mr. VOLKMER. If the gentleman would yield.

Mr. NELSON. Certainly.

Mr. VOLKMER. I'd like to know what this parking garage is going to cost total?

Mr. MOORE. The request we've had, Mr. Volkmer, in the budget for fiscal year 1986 is around $13 million.

Mr. VOLKMER. Well, what's the total going to run out to?

Mr. MOORE. That is the total for the building. What we plan to do is we do not plan, nor does our budget support, to fully equip that building, that bay so it is in fact an OPF.

Mr. VOLKMER. It's a place to park the shuttle when you don't need it.

Mr. MOORE. It's a place to park it and we may use some ground-support equipment or some other mechanical, but we've not planned to go and outfit that to the same extent we've got the other two bays outfitted down there.

Mr. VOLKMER. You really don't need it from what you just told us.

Mr. MOORE. That is correct. At this point in time we can flow the problem once that third bay is there, we believe we can flow the problem with a high use rate out at Vandenberg. You've got to realize we've got one bird out at Vandenberg. Now, if our traffic demands are such that we've got to bring all the orbiters back into the Kennedy Space Center and we cannot efficiently use the Vandenberg thing, that is another problem we'll have to deal with.

Mr. NELSON. Now, does that TPS facility, if and when you build it, is it to work with the TPS or is it to put these tiles on the orbiter. Is it to manufacture——

Mr. MOORE. Why don't you comment, Mike.

Mr. WEEKS. That is a facility like at Lockheed, that can actually make a tile.

Mr. NELSON. OK, that's what——

Mr. WEEKS. And putting the tiles on you can do in either of the OPF's today or this new facility that Jesse spoke about, you can do that kind of tile work. There will then be three places that you can do tile-type work on the orbiters.

Mr. NELSON. OK. Now, what are you doing about a cargo processing contract down at the KSC?

Mr. MOORE. As you know, at the Kennedy Space Center there were several phases in terms of processing activities at the cape. One was the base operations contract, which has been put in place approximately 2 years. Second phase were the shuttle processing contract, which has been underway now for more than a year, third phase is cargo processing. That is being discussed. I would say, Mr. Chairman, it's in a discussion phase at this point in time and there has been no clear-cut decision or recommendation that has come up to us about going forward with a cargo processing contract, at this point in time. So it is an item of discussion at this point in time. We have not reached any formal conclusions about whether we want to go forward with a cargo processing contract at this time or not.

Mr. **Nelson**. OK, how about describing the nature and purpose and cost of the contractor facility that's being built near KSC to support the orbiter maintenance requirements?

Mr. **Moore**. The nature of that is to—in a long-term objectives sense we have a logistics policy that we approved back in the April 1984 timeframe, to try to centralize our logistics support to the fleet. As part of that logistics policy we want to move, as much as we can, toward the launch site as far as logistics support. It only makes sense to be very close to where the birds are in order to provide the logistics capability. In working with Rockwell on this, Rockwell has made this proposal and we have, in effect, supported this proposal. Rockwell has proposed that they support the initiation of a logistics activity at the cape, which would bring some 20 plus equipment items down to the Kennedy Space Center for repair and maintenance. The cost of that is that Rockwell, to my understanding, has invested some $2½ million into the building and NASA's investment is on the order of $300 to $350 thousand. Rockwell was willing to do this. We, on the other hand, as I said, have a long term logistics policy to centralize and potentially provide depot maintenance, full depot maintenance capability for the fleet at the Kennedy Space Center. In fact we have an objective to accomplish this by the 1988 timeframe. We see this as an interim step toward that objective in terms of getting all the logistics activity centralized at the Cape in about the 1987, 1988 timeframe.

Mr. **Nelson**. OK, previously someone had asked you about OMV's, I think Mr. Volkmer, and I want to ask you, does the Department of Defense have use—need for the use of an OMV?

Mr. **Moore**. The Department of Defense, at this point in time, is funding some tasks in the OMV activities to the tune, I believe, of a few hundred thousand dollars. I think there's some interest there and I don't think that has been fully explored at this point in time and I don't know what the long term requirements are of the DOD, but we are continuing to have dialog with the Department of Defense on the OMV and will continue to see if there is some mutual interest that they may have also in this.

Mr. **Nelson**. And what's the price tag of the OMV?

Mr. **Moore**. The OMV has a price range of between $375 and $425 million dollars, is kind of the price range. I think our estimate for it is on the order of $375 or $380, in that area.

Mr. **Nelson**. It's your thought that DOD, if they used it, would pay a user's fee——

Mr. **Moore**. Potentially, yes, sir.

Mr. **Nelson** [continuing]. Like they do on the shuttle?

Mr. **Moore**. That could very well be a way we find to charge for the OMV. I think, however, that we have not advanced to that state right now. I think it's important that they are supporting some tasks into the OMV and I think we'll continue to have those dialog with them as time goes on.

Mr. NELSON. But, at this point you're not anticipating any development funds DOD?

Mr. MOORE. At this point in time I am not counting any on any Department of Defense development funds for OMV. I have solely included it in my budget request and my budget request will build one unit and get it ready for flight by 1990.

Mr. NELSON. OK, now how many OMV's are we going to have?

Mr. MOORE. In the shuttle program my plans are that we only have one orbiter maneuvering vehicle. There is dialog and discussion in the Space Station Program that they may require an OMV and I think that that's something they will have to comment on, but my plan——

Mr. NELSON. And that will come out of the cost of the $8 billion on the station?

Mr. MOORE. I would assume so. My budget only supports one orbiter maneuvering vehicle to be used with the Space Shuttle Program to extend the range of the STS in terms of servicing and retrieving.

Mr. NELSON. OK, now let's talk a little bit about ELV's. Do you think that the NASA design proposal to the Air Force, the SRBX, is it receiving a fair and adequate consideration as an alternative to its competition, the modified type.

Mr. MOORE. Well, I haven't seen the final decision out of the process yet, so I can't give you an absolute answer on that, but let me say that we have gone through what we would normally go through or what contractors go through for NASA proposals in preparing proposals and response to the RFP, NASA put its RFP together on it and we had a session with the Air Force people out at space division back in January. Marshall sent a team of some 14 people out—I believe out to the west coast and the reports I got back from Marshall was that it was a very good, comprehensive interchange of data and I would hope that the Air Force is, and I believe the Air Force is following the normal standard source of evaluation of Board principles and going through it a very thorough evaluation on this thing.

Mr. NELSON. When are we expecting a decision on that?

Mr. MOORE. I would say that sometime within the next couple of weeks to a month would be a guess on that decision. As you know, one part of that process has been decided and that was the process of the two proposals from industry. There were proposals from Martin Marietta and a proposal from General Dynamics. The decision was announced by the Air Force that Martin Marietta had won the competition between those two proposals and then the Air Force plans and is doing an evaluation of the Martin proposal versus the Government alternative on the SRBX. And, as I said I believe they're following the standard source Evaluation Board activities and are going through a comprehensive technical evaluation on this. I think part of the—part of the decision will be reached over—as I said, over the next couple of weeks to a month and I think it has something to do with the study that we have been doing with the Department of Defense in terms of looking at what the long-term plans are for vehicles. Do these versions have growth, etc. And to date, NASA and DOD have not agreed on a common basis for that and I think part of that is part of the reason why a decision has not been reached at this point in time.

Mr. **Nelson**. Let me ask our staff, do we have Pete Aldridge coming here before he makes his decision on the SRBX and the modified type.

I would—if he's coming on March 7, I'd like to see if we can get him here before that decision

Staff **Member**. He's out of the country.

Mr. **Nelson**. He's out of the country.

Mr. **Moore**. He's in Australia, I believe for a couple of weeks, I think.

Mr. **Nelson**. OK, you might—you might pass on that we'd like a chance to visit with him then before that decision is announced.

Mr. **Walker**. Mr. Chairman, could I ask a couple of questions in this area?

Mr. **Nelson**. Sure, by all means.

Mr. **Walker**. Do you have any real understanding as to why the Air Force has decided they have this requirement when literally their requirements drove the shuttle design?

Mr. **Moore**. No, as I think I may have said in the past, and I know Mr. Beggs has said in the past, that NASA is not in a position to second guess the Air Force decisions for this complementary ELV. We have said that if there is a requirement NASA will not second guess that requirement. In fact, the President has agreed that there is a requirement for an ELV, then our position is that we ought to use the best technology we can in terms of developing that complementary ELV system. But I can't couple your two points together from the long-term requirements that the Air Force imposed on the shuttle for their current capabilities.

Mr. **Walker**. Well, you see from my perspective, if you look back over the history of this, I mean their requirements drove shuttle design to a large extent and now they're coming in with an ELV capability, now then I have to assume that either they think you can't meet your flight schedule or they feel that they are going to have capacities or needs beyond the flight schedule that you anticipate.

Now, if they have needs beyond the flight schedule that you anticipate then that comes back to the question of a fifth orbiter. If they don't think you can meet your flight schedule then we've got—then we've got some serious concerns as a subcommittee as to why can't you meet your flight schedule that the Air Force has determined. Can you give me some reading?

Mr. **Moore**. Well, I obviously can't read the Air Force position on all these things. I can say that based on some of the things I've heard is that there is discussion that in the event the shuttle were, you know, down for some period of time, they needed to have a capability in order to launch, they'd like to have a backup capability, complementary capability in order to launch it. And they've also said they only need two per year for the period of time from like 1988 through like 1993, during this period of time, but——

Mr. **Walker**. It's a $2 billion item and for $2 billion you could buy a fifth orbiter.

Mr. **Moore**. I understand that.

Mr. **Walker**. And you know, if it's backup capability that they need, then the question becomes why not spend the $2 billion on the fifth orbiter and get your backup capability that way, rather than going with the 10 ELV's and you know, what that convinces me of is that what they're really saying is that, you know, that they've got some problems with the system.

Mr. **Moore**. Well, I think, Mr. Walker, you raise some good questions and I think these are quite appropriate to try to get responses from the Air Force on these items. I can't second guess the Air——

Mr. **Walker**. I assure you we will try to get those answers. Thank you, Mr. Chairman.

Mr. **Nelson**. OK. I want to let you know of my interest in space science and so I want to ask you the question, why aren't more space shuttle launches being devoted to space science?

Mr. **Moore**. Well, let me try to answer it in a couple of ways and hopefully not in too circuitous a way, I would say, Mr. Chairman, up to the date—up to date out of our 15 missions, we've had a number of space science shuttle. I think that the space science payloads that have probably not been launched as early as they would have liked to have been launched. There's probably some of the spacelab flights that have been moved a little bit and maybe the material sciences thing has not been launched as early as the material sciences lab, but on the whole I would say we have launched a fair number of space science payloads and as I recall in my opening remarks 1986 is going to be a banner year for space science. A number of things are coming together in that year that have been worked on for a long time, and I think our shuttle program is going to devote a large part of its efforts and are devoting a large part of its efforts now to bringing those three, four, I should say, the ASTRO-flight, the two planetary flights and the space telescope flights, get them off on time and to meet their requirements.

The other thing I would say is that fiscal year 1985 has two dedicated spacelab flights in it and fiscal year 1986 has additional spacelab flights in it, our first life sciences flight will fly, so I think overall, I think we will wind up devoting an awful lot of our efforts and flights to space science. And I would hope we get in a position, as that—as the old saying goes, "we're ready when you are", and as their payloads are ready to fly, we can fly them.

Mr. **Nelson**. Let me suggest something for you to consider, what about adding one or two additional flights, then what that would create for you, if you had a problem and that you had a cancellation of a scheduled flight, then you'd have that additional flexibility that those extra one or two flights would provide, so that you could make up for that lost flight with a minimal of disruption and, at the same time, if a problem did not occur you would have the capability of those space science payloads that they could be flown on a space-available basis. Will you consider that?

Mr. **Moore**. Yes, sir. I think if we were to talk about our longer term manifest plans you would see that, I believe beginning in fiscal year 1987 we have some reflight capabilities planned in the program. We have not been able to accomplish a lot of reflight potential in that, and that is a mission that has untagged is what I mean by having a reflight. We have, on the average, beginning in 1987, about one flight per year that's a reflight that just take into account some of these things. And if the space science payloads space science systems are ready to fly we are going to do our best to accommodate them and that may certainly be a very viable way of getting their flights accommodated in a much more timely manner.

I think, to some extent, you've got to look at the program and say a lot of the major space science activities take some time to develop, like Galileo's been underway for 6 years or so, Ulysses the same way, space telescope the same way, so we're going to see these kind of programs in the space sciences area come along when you talk about dedicated flights. What I think we've got to work on are things, like when we have space available on a flight and that's what we're working on in the hitchhiker program. We have a couple of efforts underway, one at the Goddard Space Flight Center, which is to provide a side-matted payload carrier that we can stuff into the shuttle cargo very late in the process. And this will allow us to take on experiments that we have not been able to accommodate in the normal flow of things. And at the Marshall Space Flight Center we're undertaking an across the bay hitchhiker structure that you can put into the shuttle flow very late in the game to accomplish these type of experiments.

So, I think we're trying to work very hard with the space science community and are trying to do our best as far as accommodating their requirements.

Mr. NELSON. OK, if that has any merit to it then I would suggest—I wish you'd get back to it.

Mr. MOORE. Yes, sir. We'll do that.

[The information follows:]

The following is provided in response to an inquiry during Congressional Testimony from Mr. Nelson, Chairman, House Subcommittee on Science and Applications, to Mr. Jesse Moore concerning the addition of one or two flight opportunities that would serve to increase our flexibility in accommodating Space Science payloads.

Presently, our STS mission planning includes, through FY 1989, an average of 5 or 6 equivalent dedicated Shuttle flights for the Science and Applications community. Our plans call for flying 15 payloads in 1986, and 18 payloads in 1987. Also, in 1987 we expect to be able to handle payloads of opportunity on as many as 8 other missions. In addition, we are examining options which would accommodate additional Science payloads.

We have several programs under development which respond to the Space Shuttle Science Working Group (SSWG) recommendation for increased access to the STS. The Spacelab Pallet System (SPS), a compliment of the standard dedicated Spacelab, provides two versions of a mixed cargo carrier based on European supplied pallets which will fly singularly or in pairs with other deployable cargo, and, thus share launch costs and increased flight opportunities. These are the Igloo Pallet, which will fly for the first time in March 1986, and the Multiplexer Demultiplexer (MDM) Pallet, which flew for the first time in October 1984. Similarly, the MDM MPESS (Multi-Purpose Experiment Support Structure) provides mixed cargo accommodations for smaller payloads and flew for the first time in June 1983.

The Spacelab Program is also developing another pair of carrier systems called Hitchhiker, which will meet the primary recommendations of the SSWG to provide low cost transportation and rapid response. Both GSFC and MSFC are developing Hitchhiker systems to fit into the forward two sections of the Orbiter cargo bay which are unoccupied for most Shuttle missions, the GSFC carrier hanging on the starboard side of the bay, and the MSFC carrier spanning the bay. For users with low payload weights, normally less than 400 lbs for MSFC, and 200 lbs for the GSFC Hitchhiker, these systems will allow manifesting as late as six months before flight. To make this possible, the users are restricted to fairly modest power and data management resources and must accept the mission profiles and timelines established by the primary payloads. The initial flights are scheduled for December 1985, in the

case of the GSFC Hitchhiker, and March 1986 in the case of the MSFC Hitchhiker. Initial user interest in these new systems has been high.

Mr. NELSON. All right, finally, and I want you to know that I am working under some order here, because I've imposed a self-imposed time limit on you, so that we could get to our next guest, Mr. Grier. I only have 2 minutes remaining in that self-imposed time limit.

What do you think about an extended duration orbiter? It's sort of a modest investment and it will extend the time that an orbiter can remain on orbit and that gives the science community some additional capability, what do you think about that?

Mr. MOORE. Well, we've studied, as you're probably aware, an extended duration orbiter, and I think it gets pretty expensive if you go beyond the—around the 20-day timeframe. We're talking about some real major mods, in my opinion, to the orbiter. If you're talking about a capability in the 10- to the 14-day timeframe I think that's realistic and I think it's also cost effective. I'd also like to point out that orbiter 102 has the capability and has flown already for 10 days. We flew Columbia for 10 days on the spacelab one mission. We accomplished this by putting five cryo kits inside the orbiter to provide us the additional consumables for the extended on-orbit time, and had a very successful flight.

Now, we're in the process of evaluating Orbiter Atlantis in terms of extending its capability and are committed to extend its capability out to at least 10 days, on Atlantis. So, we'll have two birds in the fleet to give us at least 10 days' capability.

Now, if requirements come up that can truly benefit from the extra 3 or 4 days, the 14-day capability, we're certainly willing to work with the community and are willing to look at the viable options in terms of achieving the additional 3- or 4-day staytime, up to about 14 or 15 days. And I think wherever missions can benefit from it, where you've got scientific missions that can benefit from additional 3 days of observation, 4 days, we're certainly willing to support those and intend to do those with the fleet.

But, I think once we get beyond that and approach the 20-day we're daying about substantial funding and mods to the system and I think space station is coming along downline, it will be in the early 1990's kind of timeframe and that will provide a more permanent duration for those kind of experiments in space.

Mr. NELSON. We heard that you recently had an inquiry from Peter Banks, the Chairman of the SESAS task force on scientific uses of the space station, with regard to the extended duration orbiter, is that true?

Mr. MOORE. We have had—we have had some interaction with the Peter Banks committee in terms of the extended duration orbiter. I have not personally had any interaction with him in the past couple of months. I'm aware that his committee is deliberating over this thing and I think their report may have been recently published in terms of the extended duration orbiter, but I have not personally had any interaction with Dr. Banks on that.

Mr. NELSON. Would you submit, for the record, that kind of interaction or correspondence that you have and what——

Mr. MOORE. I will do that, sir.

Mr. **Nelson** [continuing]. Your response to that communication or correspondence would be?

Mr. **Moore**. I certainly will do that, Mr. Chairman.

Mr. **Nelson**. All right, we certainly would appreciate that. Anybody else have a question?

[The information follows:]

We have received a letter from Dr. Banks dated February 8, 1985, which reiterates the strong support of the space research community for a low cost EDO. It states that great scientific benefit would result from even a modest increase to mission time of 12 to 14 days. It observes that it would be a great shame if NASA were to miss the chance to provide for such a great enhancement of its capabilities for space research through misunderstanding of the desires of the scientific community. A copy of that letter is attached for the record.

For extended missions of less than 20 days, we have identified several areas in which missions of approximately 14 days would have utility: vapor and solution crystal growth, high thermal gradient growth crystals, developmental biology, cosmic ray detection, solar data during an entire pass and full Earth coverage from polar orbit. Two additional potential uses have recently been suggested: developing greater experience in Spacelab missions which might provide insight into Space Station operations, and providing several additional days of Shuttle on-orbit time during Space Station assembly operations. While the cost of Shuttle modifications to permit mission durations of between 14 and 20 days is considerably less than for missions beyond 20 days, they are still substantial. They also require development periods of 2½ to 3 years, and result in other restrictions in Shuttle capability. Depending on the particular modifications, these restrictions on other aspects of Shuttle performance include payload weight, dimension and c.g. limitations, attitude constraints, field of view restraints, storage restrictions and turnaround time.

Our present plan is to upgrade a second Orbiter to a five cryo tank set (10 day) capability, i.e., in addition to OV-102 (Columbia) which already has this capability. It had been planned to add this capability to OV-104 (Atlantis) during its build cycle. Although this was not done and cannot be done now without impacting the delivery date from Palmdale, we are still committed to configuring a second Orbiter for this longer duration. We will keep Dr. Banks advised on these matters directly, as well as through our representatives on his task force.

Mr. **Walker**. Just one, Mr. Chairman.

Mr. **Nelson**. Sure.

Mr. **Walker**. I'm concerned about, as we look at the budget scenarios now, when we start talking about the 24 missions a year on the shuttle, that we are really getting toward the point where the shuttle operations could drive the entire NASA budget. That it will be such a major component of NASA's budget in the out years that we will run into problems in terms of being able to do other things particularly R&D kinds of things at NASA. Is there any reason to share, that you share that kind of concern.

Mr. **Moore**. Well, I—as you probably know, Mr. Walker, there were several studies that have been done and have not been totally completed, that have looked at; One, fencing shuttle operations to try to insure that shuttle is separate and doesn't get embedded to where it gets masked in other NASA operations, as well as the Smylie Committee that Mr. Beggs appointed back in the Summer of last year, in terms of looking at long-term shuttle operations and transitions and so on. Both of those reports are in draft stages and have not been finalized at this point in time and I would have to say that, yes, you can think about those kind of things happening, but if one is careful in terms of positioning the budget you can clearly see what you're spending on the shuttle. And, if it turns out that it's not, you know, too expensive for what you think it's delivering we can wind up looking at the shuttle adjustments, but I think there is an adequate approach to trying to separate out shuttle operations from the rest of the Agency so that that ought to be clear and we can always have visibility in——

Mr. WALKER. Are we going to have those reports available by the time we have to make our authorization judgments in this subcommittee?

Mr. MOORE. I can't give you an affirmative on that. I know that both of those reports are in draft, at this point in time, and they are being internally reviewed with the Agency. I will go back with your comment on that and see if we cannot get those done, but I cannot promise that here today.

[The information follows:]

The "Report to Congress on Shuttle Operations Fencing" was sent to Congressman Fuqua on February 26, 1985.

The Shuttle Operations Strategic Planning Group, chaired by Mr. E. Smylie, has reported to the Administrator and their report will be provided to Congress shortly.

Mr. WALKER. One final question, do you have an estimate of the cost per flight for shuttle in fiscal year 1986 and the cost per flight projected for fiscal year 1988?

Mr. MOORE. Well, the cost per flight—let me tell you what I—what I have got in terms of the—in terms of the 1980—let me answer it by talking about the cost per flight in fiscal 1989 and I'll back up from that, if I can.

Mr. WALKER. Yes, and give me—tell me how many number of flights per year that's for.

Mr. MOORE. Very, very important, as you well know, that the number of flights you assume and the average cost is very, very important. In our recent cost base we've estimated that the cost—average cost for a shuttle cost in fiscal year 1989 through the—like the 1992 timeframe is like, $83 million, and that is for 24 flights. Now, Mack, do you have the other data here in the fiscal year 1986 and the fiscal year 1980 numbers—1988 numbers and the corresponding flight rates?

Mr. STEEL. Well, consistent with the data that Jesse just provided is the average from 1989 and 1991. The fiscal year 1988 estimated cost is around $88 million per flight and backing that down to 1986, it's approximately $120 million.

Mr. MOORE. Give them the corresponding flight rates on that, because that is extremely——

Mr. STEEL. Oh, I'm sorry.

Mr. MOORE [continuing]. Because that is extremely sensitive to flight rate, as you well know, Mr. Walker.

Mr. STEEL. Our 1986 budgeted flight rate is 17. I'm sorry, excuse me. The 1986 rate is 14, I'm sorry. And in 1988 it's 19.

Mr. NELSON. All right now, as you know, we are starting a series of hearings on, and Bob, I want you to be a part of this, we're starting a series of hearings tomorrow on the shuttle pricing policy and 2 weeks from now we have—we have the offerors and customers that are going to be testifying tomorrow.

Mr. MOORE. Yes, sir.

Mr. NELSON. And then in 2 weeks we're going to have Government agencies, including Jim Beggs and you back——

Mr. MOORE. Yes, sir.

Mr. NELSON [continuing]. And we're going to really dig into this. Now, I want to make sure that we're going to be having the opportunity of your good judgment on this before this interagency space group makes the decision——

Mr. MOORE. Yes, sir.

Mr. NELSON. OK.

Mr. MOORE. We have not, as you well know, in responding to the NSDD-144 from the President, back in August, we submitted a price for the shuttle in 1988 through the—in the 1989 through the 1992 timeframe. We have not had a response back from that, and this group has been looking at that. In fact there has been a lot of—a lot of activity on the STS pricing policy, as you well know, in fact, we've continued to study our posture on the STS pricing policy and it's a very important issue, I think, for not only we at NASA, but the Nation to address. I think it has a lot to do with the long-term future of the shuttle. Competition, foreign competition, balance of trade, satellite services and things of this nature. So I think it's a very important issue.

Mr. NELSON. OK, and as part of this I want you all to, perhaps you need to do with privately with us, to have the National Security Council point of view weighed in with us at the time that we are discussing that. If this has to be a closed door meeting for the subcommittee then so be it, but I want that security standpoint before this committee.

Mr. MOORE. Yes, sir.

Mr. NELSON. And we will be going into this, it is my intention, as Chairman, to get into this in a vigorous manner——

Mr. MOORE. Yes, sir.

Mr. NELSON [continuing]. On the question of shuttle prices.

Mr. MOORE. Yes, sir.

Mr. NELSON. But, my concern with my question was that we're not suddenly not going to have a decision made within a short period of time, and you're saying, no, that is not——

Mr. MOORE. Not to my knowledge, Mr. Chairman. I just asked Mr. Beggs, I think, addressed and answered in response to Mr. Fuqua's test question, I guess, a week or so ago. The expectation is that we will not have a decision reached in the very near future.

Mr. NELSON. OK, well you have been most eloquent. I might pass on that out there in the field, and I visited Houston and Huntsville this past week, and you are thought very highly of out there in the field. So that's a compliment and a testimony to your good work.

Mr. MOORE. Thank you, very much, Mr. Chairman.

Mr. NELSON. We appreciate your being here.

Mr. MOORE. My pleasure.

Mr. NELSON. Thank you.

Let's call Mr. Grier up. He's been waiting patiently back there. Mr. Grier is a member of the Aerospace Safety Advisory Panel, which is a group that is advisory to NASA on, just what its name implies, aerospace safety. And Mr. Grier has been kind enough to fill in, on short notice for the Chairman, Mr. Brizendine, who is presently in the hospital. And so, that's very kind of you, Mr. Grier, to do that and you may proceed and then we'll have a few questions for you and we'll get you out of here by 4.

STATEMENT OF HERBERT E. GRIER, MEMBER, AEROSPACE SAFETY ADVISORY PANEL, ACCOMPANIED BY JOHN REEDER, CHARLES DONLAN, NORMAN PARMET, SEYMOUR HIMMEL, AND JOHN STEWART

Mr. GRIER. Fine, thank you, Mr. Chairman and members of the committee. I am Herb Grier and I am a former member of the panel. I was Chairman at the time when we were in the major experimental part and then we—the panel shifted gears and got more into the operational influence, Willis Hawkins was the chairman and now John Brizendine is. We have here with us, to answer questions, some of the members, Mr. Parmet, Donlan, Reeder, Himmel, and Gil Roth, our staff director and I think between us we can answer any of your questions.

Copies of our annual report have been presented to the staff and I'm not sure they have circulated as yet and copies of Mr. Brizendine's report, which he would have presented today.

Mr. NELSON. OK, Mr. Grier.

Mr. GRIER. Yes, sir.

Mr. NELSON. If you want to just summarize, we can take your statement and insert it in the record, so it will be a permanent part of the record, and if you prefer, orally, to summarize it will be your pleasure.

Mr. GRIER. Fine, I will do that.

Mr. NELSON. OK.

[The prepared statement of Mr. Brizendine follows:]

STATEMENT OF

JOHN C. BRIZENDINE
Chairman of the
Aerospace Safety Advisory Panel

before the

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

Mr. Chairman and Distinguished Members of the Subcommittee:
It is a pleasure for me to appear before this Subcommittee with my first year as Chairman of the Aerospace Safety Advisory Panel now completed. Our purpose today is to present and elaborate on the results of our activities during calendar year 1984. The focus of our activities was directed toward three broad areas of NASA's responsibilities:

1. The Space Transportation System (STS) operations and evolving progam elements,

2. Establishment of the Space Station Program organization and issuance of Requests for Proposals to the Aerospace Industry, and

3. NASA's aircraft operations including research and development flight programs for two advanced "X-Type" aircraft.

The majority of the Panel's time has been spent on the Space Transportation System as the tempo and complexity of the missions increase.

Before discussing the Panel's findings and recommendations, it is worthwhile to note that during our visits to six NASA centers, seven contractor sites, and Vandenberg Air Force Base, the government and industry support provided was thorough and timely. There were a total of thirty-six fact-finding sessions conducted during 1984 in addition to our appearances before congressional committees.

The complete annual report delivered to NASA contains substantial detail in support of the Panel's findings and recommendation; a list of Panel members, consultants and staff; discussions of past and future activities; and other supporting information.

SPACE TRANSPORTATION SYSTEM

The Panel's 1984 Annual Report received a great deal of consideration with both oral and written responses. The written response is included in this year's report as an appendix. Most of the items are now considered "closed" based on either adequate explanation or implementation or plans to accomplish the appropriate actions. There are, however, some items that continue to be of interest:

- The Panel continues to believe strongly that there are benefits resulting from reducing landing speed of the Orbiter, for example, better pitch control at landing, and lower landing gear loads. A specific solution such as canard control surfaces may impose too great weight and mechanical problems but the Panel urges NASA to continue to seek other, perhaps more adapatable solutions.

- Other major areas include the continued product quality of all major components, Orbiter external thermal protection subsystem or tiles, Orbiter structural adequacy to allow flight envelope expansion, continued improvement of the Space Shuttle Main Engine, and the launch preparation activities at both Kennedy Space Center and Vandenberg Air Force Base.

- Of lesser importance is maintaining touch with activities associated with the Orbiter brake and landing gear subsystem, nose-wheel steering, new Auxiliary Power Units, and upgraded General Purpose Computers.

Before discussing the findings and recommendations it is worthwhile to make the following points which we have stated before:

- The Space Transportation System is still in transition from the "single event demonstration" stage to "operational" stage, and will remain such until the full operational capabilities (and limitations) are known in quantitative terms,

- Complacency bred of repetition is an inborn human hazard and conscious steps to avoid this are essential,

- Changes to hardware and software must be controlled to the degree necessary to avoid overloading the processing team's ability to safely implement them,

- Changing contractor and personnel arrangements must be carefully planned in advance,

- Product quality is not just a phrase or a management system but something that requires strict discipline and is everybody's business everyday,

- The logistics aspects must be supported by its current level of funding and management attention.

The Panel's findings and recommendations applicable to the Space Transportation System are as follows: (These are somewhat abbreviated from that found in the report.)

1. Launch Processing and Logistics

Findings

The transition to the Shuttle Processing Contractor (SPC) was achieved in early 1984. The SPC and NASA are both to be commended for commitment of effort and dedication to success of the concept.

Each subsequent launch processing sequence to date has generated an unexpected burden of modifications, change-outs, repairs, and maintenance tasks. Launch processing has thus been anything but routine.

The Shuttle Processing Contractor (SPC) is struggling to handle the burden of work associated with each mission. The problems arise in part from difficult engineering tradeoffs and need for sufficient advance planning of modifications to the Orbiter; unexpected replacement of parts; some shortage of qualified spares at KSC; lack of necessary piece parts; some shortage of qualified technicians in certain disciplines, and heavy paperwork burden. The SPC must also assume launch processing responsibilities at Vandenberg Air Force Base using many of the same persons working at KSC.

Although serious, these transitional problems are neither unusual nor unexpected, given the complexity of the STS. The challenge to NASA is to move through this period of "developmental evolution" in a way that makes feasible a sustained period of "operations" into the next century. In other words, efforts and expenditures now to improve the reliability, maintainability, and safety of key STS systems should pay off handsomely in future years.

Recommendations

1. NASA management should continue to allocate the human and financial resources required to maintain acceptable levels of safety in what in many respects is still a developmental program.

2. Modifications to the Orbiter should be directed at improving reliability, maintainability, and safety as well as achieving additional increments in performance.

3. NASA management should make a concerted effort to identify and prepare for Orbiter modifications prior to commencement of the launch processing sequence. "Freeze point" discipline must be maintained. Unexpected changes and modifications must be held to a minimum if the Shuttle Processing Contractor (SPC) is to achieve the projected flight rate.

4. Vesting overall Shuttle management in an "operations entity" at NASA Headquarters would help achieve acceptable levels of efficiency, productivity, and schedule reliability during this period of "developmental evolution." The Panel has made this recommendation in past years and NASA management is presently examining this and related issues through the Shuttle Operations Strategic Planning Group, the Smylie Committee.

5. NASA management would be well advised to avoid advertising the Shuttle as being "operational" in the airline sense when it clearly isn't. Given this reality, the continuing use of the term "operational" simply compounds the unique management challenge of guiding the STS through this period of "developmental evolution." NASA should continue to focus on making the STS as efficient, productive and reliable as possible while the research and development flights are defining the commercial use of space.

2. Space Shuttle Main Engines (SSME's)

Finding

The three phase program to improve the SSME that was initiated last year has been restructured so as to provide a long term SSME technology program while staying within the FY 1985 congressional budget. The modified program will not achieve all of the original objectives. It will, however, result in a more reliable and durable engine for operation at 104% Rated Power Level (RPL) thrust with significant margin. Operation at 109% RPL thrust with improved but limited life, under hardware performance constraints will be possible. To achieve additional margin and/or additional life at 109% RPL thrust requires the incorporation of the large-throat main combustion chamber now relegated to the "Precursor" program, a technology-oriented program looking at long-range engineering advancements.

Recommendation

The modified improvement program should be pursued vigorously. All reasonable effort should be exerted to develop the new hot gas manifold and to incorporate it at the earliest date feasible. Activity to reduce start and shutdown temperature transients should be added to the"Phase 2+" program. Mission planning should continue to consider 104% RPL thrust as the normal operating level for the engines. 109% RPL thrust should be employed only for those missions dependent on the higher thrust and as an abort capability.

3. Space Shuttle Solid Rocket Boosters (SRM/SRB)

Finding

The Solid Rocket Motor filament wound case may exceed flight to ground system clearance interface limits due to the filament wound case being more flexible than the steel case. Data indicate that the modal frequencies of the filament wound case are even lower than first estimated due to filament wound case joint free-play.

Recommendation

An analysis and tests be performed on the filament wound case with the total stack to establish lift-off loads and vehicle excursions considering the lower modal frequencies.

4. Orbiter Structural Life Certification and Structural Adequacy

Finding

The structural life certification program for the Orbiter is based on supplemental full-scale tests. However, two extremely important tests on the wing have not yet been conducted which leaves the certification plan incomplete. The full-scale test for these two articles are very expensive and show negligible fatigue damage based on a current simple analysis.

Recommendations

The Panel agrees with the decision to certify these two articles by analysis. A detailed analysis plan for the two test articles should be developed and implemented to fulfill the certification program for 100 missions.

Findings

The Space Shuttle has to fly in regimes requiring high performance missions with adequate launch probability. A new Loads/Thermal/Stress cycle program, now in progress, is an important part of certification, since flight-measured data show that the wing normal forces were larger and more aft than prior analyses indicated. The current loads/thermal/stress cycle will not be completed until 1987. In the meantime, the Orbiter capability assessment (OCA) plan, employing current algorithms, derived from flight test, has been used to make launch decisions using a negative q profile resulting in loss of performance. Some wing/fuselage modifications have been made and others have to be completed in order to expand the Orbiter flight trajectory for future flight missions.

Recommendations

Conduct a systematic review and document the structural differences, safety margins and major logistics impacts for each Orbiter vehicle. In recognition of these differences, baseline the performance envelope for each Orbiter and, as required, determine the trade-offs between any structural/aerodynamics modifications and performance.

5. Space Extra-Vehicular Activities (EVA's) and Life Sciences

Finding

EVA will continue to be extensively used, both planned and impromptu. The Space Station will require considerable EVA initially for its construction and later for operational activity. While the current suit has performed well, within its limitations, there is need for a new EVA suit with improved flexibility and higher internal operating pressure. Such a concept is in the early development phase in NASA and needs to be funded for further development and possible production as a replacement for the current EVA suit.

Recommendation

NASA should encourage the development of an advanced higher pressure EVA suit to replace the existing unit.

6. Use of Orbiter-102 in R&D Role

Finding

In responding to pressures for improved performance there will be a continuing need to expand the STS ascent and Orbiter descent flight envelopes (trajectories) creating the need to obtain flight data measurements relating to structural loads and aerodynamic behavior.

Recommendation

Orbiter OV-102 is the most suitably instrumented of the Shuttle fleet and should regularly be utilized as a research and development vehicle in addition to its normal mission activities.

7. Kennedy Space Center (KSC) and Vandenberg Air Force Base (VAFB) Common Operations

Finding

In the near future, at least in part, common launch crews will be used at both KSC and VAFB and unless the schedules are coordinated conflicts may arise, particularly in the case of DOD's "on demand" launches. The conflicts may not be restricted to schedule but also as to vehicle.

Recommendation

Until such time as the KSC and VAFB sites have their own launch crews and dedicated Orbiters, the manifesting or scheduling activity should have a procedure to consider the schedule effects on crews who must travel back and forth. Also, attention must be given to the availability of specific Orbiters that may be required by specific missions. This is particularly critical in those cases where the DOD may be required to ask for an unscheduled launch.

8. Shuttle/Centaur

Finding

The development of Centaur for Shuttle is on a very tight schedule. With but 30% of system weights being actuals, performance margins for the currently planned planetary missions are quite small and expected to decrease. Resolution of issues raised by some of the requests for safety waivers submitted by the Centaur project has not yet been achieved. This is a consequence of additional operational constraints introduced by the inclusion of abort modes for the Orbiter that do not provide the originally specified time for Centaur propellant dumping. There is also an issue concerning the interpretation of certain specifications for some Centaur fluid system components.

Recommendation

While acknowledging the fact that the issues are being addressed, the Panel urges that the matter of the safety waiver request and the interpretation of specifications be resolved with careful deliberation. The ability to make and incorporate significant design changes for Centaur G' within the time remaining to the planetary opportunity for Galileo is fast diminishing. With the major portion of the Centaur G' qualification test program remaining to be conducted, it would be highly desirable that the Centaur project staff be able to concentrate on insuring that the test requirements are met.

9. Radioisotope Thermoelectric Generators (RTG's) for Galileo and Ulysses Missions

Finding

Both the planetary Galileo and solar Ulysses missions employ RTG's as the spacecraft power source. Obtaining clearance to fly such nuclear systems is a complex matter both technically and managerially. Relatively recently it was recognized that the capacity of the RTG fuel elements to survive overpressures that might be encountered under certain launch system failure modes might be less than had been anticipated. Concurrently, it was found that there were disagreements about the interpretation of experimental data used to estimate overpressures that would be generated for certain failure modes. Also, the probabilities of the several failure modes had not been agreed upon. During the last half of 1984 steps were taken by all organizations involved to resolve the issues in a fully coordinated manner.

Recommendation

The Panel endorses the proposal made by the ad hoc committee that addressed the issue to improve coordination among the organizations involved by appointing a "single point of contact" on this subject for each organization. Further, the Panel endorses the recommendation to assign prime responsibility for obtaining flight clearance to the science mission center, Jet Propulsion Laboratory (JPL).

SPACE STATION

In response to the President's directive NASA has initiated a number of actions directed toward attaining a permanently manned Space Station within a decade. In meeting its statutory objectives the Panel has begun to review this new program in ever increasing depth. Early exposure is necessary to fully understand the coming progression of events as well as allowing Panel input at the appropriate times. The Panel's areas of interests in Space Station include manned transportation, construction, residency, operations, maintenance, extra vehicular activities, hazard exposure, escape and rescue. From the technical management view we are interested in the safety organizations and safety requirements associated with both domestic and foreign participation. We will be looking at the program's manned base as well as the interfaces with unmanned platforms and other vehicles, and specific areas such as the Life Sciences and Space Medicine consideration such as the space adaptation syndrome as well as the on-orbit maintenance "driver."

NASA AIRCRAFT OPERATION

Safety of aircraft flight operations for both administrative and R&D vehicles is a top priority with NASA. To continue to meet their high standards the NASA Administrator has provided specific guidance regarding flight operations policies and procedures. The NASA Headquarters Aircraft Management Office has taken a number of steps including appropriate management instructions to be followed up by an assurance program with periodic reviews of each NASA center's flight operations and safety program. Specifically our annual report notes the following finding and recommendation:

Finding

The record over the past year has been good. Progress is being made in providing up-to-date flight standards for both transport (administrative) aircraft and for experimental aircraft. Aircraft operations management resides in the Aircraft Management Office at Hadquarters which reports to the Associate Administrator for Management. It is the Agency focal point for all NASA aircraft policy and related matters. The responsibility for development of flight standards is still somewhat fragmented as it is currently left to the various centers to establish and maintain them. The Aircraft Management Office has requested the

Intercenter Aircraft Operations Panel to provide a "guidelines" document to serve as the basis for the management instruction to be issued by Headquartes giving central direction covering all NASA aircraft operations.

Recommendation

The Aircraft Management Office as the Agency focal point for all aircraft operations and related matters should include, if practical, an aviation safety function. The NASA centers would benefit by a single reporting location at Headquarters.

We are monitoring the X-29A flight test program for which NASA is the lead agency for an 18-month cooperative program. Plans are to fly the airplane within a limited flight envelope until early summer when the airplane will begin a downtime period to receive an updated flight control system prior to resuming flight testing. We are also looking at the "X-Wing" project, a derivation of the Rotor System Research Aircraft. Both of these involve advanced engineering and manufacturing techniques.

Panel Activities for 1985

Specific areas of interest will include the following, which, of course, may be modified as the fact-finding activities develop and as new concerns are brought to the Panel's attention from within NASA as well as external sources:

1 Space Transportation System - The Panel will continue to assess Orbiter structures and functional subsystems; the External Tank if significant modifications are made to it; continued review of all aspects of the Space Shuttle Main Engine program; Shuttle Processing

Contractor/NASA progress at KSC and VAFB as the flight rate increases, hardware ages and a new launch site becomes operational; design modifications to launch facilities to accommodate increased Filament Wound Case/SRB excursions, Centaur integration, and bringing the second launch pad into operations at KSC; human factors associated with increased flight rates; Solid Rocket Booster steel case reuse, and Filament Wound Case qualification for flight along with the potential use of hybrid cases, i.e., mixed FWC and steel. From a logistics viewpoint the Panel expects to look at:

- The problems associated with obsolescent parts.
- Adequacy of the publications with regard to such things as the correct reflection of the configurations of each individual Orbiter and the incorporation of the data gained from trouble-shooting experience.
- The plans to assure spare SSMEs and/or spare high pressure fuel and oxidizer turbopumps.
- The development of an overall comprehensive maintenance plan for the entire STS system including Orbiter and SSME overhaul up through 1990.
- Meeting or advancing the 1988 date for final "spares lay-in to support maximum flight rate".
- The transferring "sustaining engineering" activitis from JSC to the operating bases at KSC and VAFB.

2. Payloads - The several upper stages in so far as they affect mission safety. The Inertial Upper Stage (IUS) under USAF cognizance and the Payload Assist Motors

(PAM's) a commercial development, will be covered at a low level of activity. The Shuttle/Centaur G' and G vehicles and their support activities will continue to be reviewed. An area of some special interest because of the new and untried aspects is the Tethered Satellite System, as will be any internal/external experiments which can have an effect on safety of the STS missions.

3. Space Station - As a developing program it is the Panel's intention to maintain close touch with the NASA organizations involved. Where practical, we will provide feedback as we achieve a more thorough understanding of the underlying concepts, philosophy and their implementation. For example, the degree to which "lessons learned" from NASA and commerical operations of high-tech facilities are applied, and the evolution of the NASA organization its relationships with industry.

4. NASA Administrative and R&D Aircraft Operations - The Panel will continue to participate in the Intercenter Aircraft Operations Panel and aircraft safety meetings. Additional time will be spent on the X-29A program as it is flown by NASA personnel in an "X-type" R&D program. The X-Wing progam will also be examined with an eye toward assuring that the review system and the safety network are adequate.

5. As appropriate the Panel will support NASA as it is requested to fulfill its obligation to both NASA and the Congress regarding safety of NASA activities and public safety as well.

Mr. **Grier**. During the 1984 year we looked principally at the Space Transportation System, that's where, if you will, the action has been and the money has been spent. We also started getting into the space station, its concept. We looked at their request from industry for proposals and we're coming up to speed on that and I think in a time where we can put input into the design process and not wait until the hardware is built and then try to influence it.

So, that started up and that's going to be a bigger and bigger share of our work, as time goes on. We've also looked at NASA's aircraft operations. The X-Wing, the aeronautic kind of programs where, indeed, safety, in a smaller way, is just as important as it is in the space shuttle.

One of our functions, really, is to follow up on our past recommendations and see what's coming out of that and what things do we have to continue to look at. NASA has very well closed out the 1983 report, during 1984 and there aren't many issues that still remain and what have—what are there are really the continuing kinds of monitoring things that we should do. For instance prevent the routine operations from getting people's thoughts drift elsewhere and you need to sharpen, to audit occasionally and that sort of thing.

So, that we're satisfied that the 1983 report has been closed out satisfactorily. We've done a lot of work, I guess we've changed our mode of operation a little bit. We're having about, oh, half a dozen formal reports of the whole committee, but we've divided up into groups of one or two and going and looking at specific operations. We have made some 36 ventures out into the system to study this past year, and I think, have covered a great many more points than we have in the past when we were more formalized into a meeting of the whole group. It certainly has helped out relations with the field process and we're getting great cooperation and I think are really doing a helpful job to NASA, rather than just simply being a panel that comes around and looks occasionally.

This 1984 year we have made some findings and we've made some recommendations and let me run down the recommendations as a way of summarizing. We've looked at the shuttle processing contractor, we've been worried about the efficiency of this operation as they begin to get toward 24 operations a year and strongly supported the shuttle processing contractor. The gathering together into one unit of all that work, and I guess we're finding and the shuttle processing contractor is finding, that none of these operations are routine. They're learning there are modifications to the shuttles, individual shuttles have individual characteristics. The four are not identical and it's quite a job to integrate this into a given mission, and it's going well. And, I guess the thing that we're trying to point out is that they should not look at it as routine. They should not really assume that everything is going to just flow from hereon and so we've asked them—we've recommended that they continue to monitor this, to do the modifications in an orderly way and that sort of thing. And I'm sure this will continue, but it needs to be pointed occasionally.

The space shuttle main engine has been a real problem over the years, not in its performance, it's done exceedingly well, but it just simply is a way-out development. It's not yet achieved the life that was originally proposed at the levels, energy levels that were required. We've recommended they keep 104 percent as an operating level of the engine, energy level, and it does have a 109 percent capability, but you really don't know the life at that, and so let's retain that for an emergency capability or there are several—a couple really, of heavy-lift missions on the books and you may have to use 109 percent then. But, let's get on with the refinement of the development of the engine. The engine development plan has been cut back a little bit because of funding, but it seems to be well underway and will achieve by the 1990's, the kind of performance originally planned.

The solid rocket boosters have really been stellar performers and the switch to the filament wound cases, in order to gain lift, has gone exceedingly well, but they're flexible and hence there is a problem that on the pad the weaving under the various forces as this thing is ignited may exceed the tolerances available, clearances between the shuttle and the launch structure.

That is being looked at, and looked at very carefully. We've followed some of those measurements and some of the analysis and we feel it's satisfactory and we also feel that long term that's going to be a good development, not only is it lighter and gives more efficiency, but really there's no reason why that can't be as reusable as the steel case, and I think that will be borne out and it will be one of the efficiencies that come in the system.

The Structural Life Certification Program for the orbiter itself has not been completely finished and there are some very tough tests to do and all the engineering people have been looking at this and they have finally come to the conclusion that several of those tests are really not worth doing over analysis. They feel that they know now, with the data they have gotten so far, that they can do an analysis job and we have supported that and say that's what they should do. That's, again, a savings of money and I don't think a risk is involved

The problem of each orbiter being a little bit different says that you've really got to begin to put into the computer the characteristics of an orbiter and you've got to begin to match the characteristics of payloads with the orbiter and that kind of puts a little different light. We thought, for instance, that you could assign an orbiter to Vandenberg or you could assign an orbiter to Kennedy and that's not quite so. It depends on the characteristics of the payload. Also, they're using the same launch crews until they get a rate at Vandenberg that will effectively warrant putting a crew there full time. And so, you've got a problem of orbiters, people and the DOD's having, and I think properly so, to schedule launch on demand. If they have a satellite expire and they may need to replace it and so we're recommending that they get a procedure for an interaction of the planning both Vandenberg and Kennedy to take into account the crews, the availability of particular shuttles and the spector of a launch on demand kind of thing and that's underway and I think will be very useful as they get towards the 24 a year.

Those were our main things. We looked at the Centaur and that's a very difficult problem. The Centaur was developed as an unmanned vehicle and hence its philosophy of design is a little different than the shuttle. The minute you bring it into the shuttle bay and try to integrate it you begin to have to accept hazards that you wouldn't allow if you were building it as a shuttle in the first place, so is it a payload or is it a part of the shuttle and what set of criteria do you use and time is getting awfully short so that some of these questions have to be resolved and we've said, "get on with it, boys," and if you can streamline the procedure for integration and that sort of thing, but it needs attention. It needs management attention, because they still have a lot of testing to do and you've got to decide what criteria you test against and I think they've speeded up, but it's—time's awasting.

And there's another aspect of that. Those payloads require nuclear power sources. My background is from the nuclear business, so that this doesn't bother me particularly and I know there's a procedure you have to go through and it's a Presidential waiver, if you will, to fly such a thing. From my perspective I don't believe it's a real problem, but it tends to bother the safety groups and it's going to, I think, be a continuing problem that they're going to have to face in any, if you will, public, civilian sort of activity that uses nuclear energy and this is a problem that these people in NASA can't really face, but I think somebody's got to face and perhaps your committee could say, "Look, we've got to come to a decision on these things." And I think that's our recommendations in a nutshell.

Mr. NELSON. OK, Mr. Grier, let's recognize the rest of the members of your advisory panel that are here. And let's recognize them personally.

Mr. PARMET. Norm Parmet.

Mr. NELSON. OK, say your name again.

Mr. PARMET. Norm Parmet.

Mr. NELSON. Mr. Parmet?

Mr. PARMET. Right.

Mr. DONLAN. Charles Donlan.

Mr. NELSON. Mr. Donlan.

Mr. REEDER. Jack Reeder.

Mr. NELSON. Mr. Reeder.

Mr. HIMMEL. Sey Himmel.

Mr. NELSON. Mr. Himmel.

Mr. HIMMEL. Yes.

Mr. NELSON. Well, we appreciate your being here and our best wishes for a speedy recovery to your chairman's wife. Any questions from the members? Mr. Walker.

Mr. WALKER. Just one. Could you be more specific about what the safety problems you see that there are inherent in the Centaur accommodation?

Mr. GRIER. They're primarily the abort problems. The Centaur itself is essentially single string, rather than multistring, but that really effects the, if you will, the probability of the Centaur part of the operation being right, so that's not a safety of flight or a safety of personnel problem, but it is a safety of mission and it is a pretty good machine.

The abort problems are that the tremendous amount of fuel and oxidizer in the Centaur tanks has to be dumped if you're going to bring it back and on a once-around-abort or on a return to launch site abort it's a harried operation to get all of that oxygen, hydrogen out of the Centaur safely overboard and the time line is very short. The—you don't have great big pumps like you have to fuel the external tank at the launch pad, it's just simply got to go out by the pressure in the tanks and that's a tough operation from a safety point of view. It dumps out the side of the vehicle. You've got APU's running at that time, they exhaust out the side. It just isn't nice.

Mr. WALKER. Thank you, Mr. Grier.

Mr. NELSON. Your charter would probably include the safety aspects of launch and landing from the standpoint of intrusion of aircraft into the launch and landing area. We've had that problem at the Kennedy Space Center. Have you all ever addressed that or do you think that that's appropriate to be addressed?

Mr. GRIER. We haven't because basically that's, if you will, an ATC, air traffic problem. And we also don't look at railing on stairways and things—we just are too small a troop to get into all of the nitty gritty safety problems and we try to kind of stay with the philosophy of safety and is their management system proper to achieve safety and no, we do not do things like worry about whether they hit——

Mr. NELSON. OK, any further questions from the committee.

Mr. Grier, thank you very much.

Mr. GRIER. Well, thank you.

Mr. NELSON. Appreciate your presentation. It was excellent. Have a good day. The committee is adjourned and we will now convene an informal organizational meeting of the committee. Why don't we just gather around the table right there.

[Whereupon, at 4 p.m., the subcommittee recessed to reconvene at the call of the Chair.]

1986 NASA AUTHORIZATION

THURSDAY, FEBRUARY 21, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:05 p.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

[The prepared opening statements of Mr. Nelson and Mr. Walker follow:]

Opening Statement of Hon. Bill Nelson, a Representative in Congress From the State of Florida

Today we begin the first of two days of hearings on the subject of Space Shuttle pricing policy. At issue is what price should commercial and foreign customers be charged for Space Shuttle launches in the 1989-1991 time period?

The ultimate answer to this question will likely have a major impact on both the expendable launch vehicle community and the space user community. Accordingly, the purpose of today's hearing is to receive testimony from representatives of these two communities to determine what would be the likely impacts of different Space Shuttle pricing policies on their respective business ventures.

At a subsequent hearing, now scheduled for March 5, the Subcommittee will receive testimony from Government witnesses to determine the perspective of federal agencies on this issue.

The witnesses that will appear today have been organized into two separate panels—an Expendable Launch Vehicle Operators Panel and a Users Panel. The Expendable Launch Vehicle Operators Panel will be composed of Mr. Antonio Savoca, President and Chief Executive Officer of Transpace Carriers, Incorporated, and Dr. Lee Scherer, Director for Commercial Space of the General Dynamics Corporation.

The members of the Users Panel are drawn from four different segments of the user community:

From the communications satellite builders and operators segment of the community we will hear from Dr. Robert Roney, Vice President of the Space and Communications Group of the Hughes Aircraft Company and Mr. Michael Lyons, Vice President and General Manager for Space Resources of Satellite Business Systems.

From the upper stage manufacturers segment of the community we will hear from Mr. Charles Ordahl, Vice President for Space Programs of the McDonnell Douglas Astronautics Company and Mr. David Thompson, President of the Orbital Sciences Corporation.

From the space platform builders and operators segment of the community we will hear from Dr. John Townsend, President of the Fairchild Space Company, and

From the segment of the community that is undertaking materials processing in space initiatives, we will hear from Mr. James Rose, Director for Electrophoresis Operations in Space of the McDonnell Douglas Astronautics Company.

Gentlemen, I would like to thank all of you for being present today to present your testimony on this important topic.

But, before proceeding with the witnesses' testimony, I would like to recognize the Ranking Minority Member of the Subcommittee, Mr. Walker, for an opening statement.

OPENING STATEMENT OF HON. ROBERT S. WALKER, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF PENNSYLVANIA

Good afternoon, Mr. Chairman. I would like to join you in welcoming our witnesses.

This afternoon we begin to address the most crucial issue in space policy for the remainder of this century.

I strongly believe that man can achieve almost limitless benefits through space commercialization. There are studies which indicate that we can develop a trillion dollar space economy over the next twenty-five years. By the year 2050 space commercialization could reach four and a half trillion dollars a year!

The key to that economic growth is manned access to space and a continuing return capability. Space materials processing of new pharmaceuticals, unique crystals, and new glass and ceramic materials will be the foundation of the economy of the future.

It is obvious that the space shuttle is the cornerstone of the Space Station and space lab facilities where most of the processing will occur. I now believe that NASA has not been vigorous enough in aggressively pursuing private and foreign investors to fund a fifth orbiter and beyond. In the end I believe we will have to spin shuttle to either a quasi-governmental agency or some private operator to protect NASA from seeing other programs being strangled by shuttle operations.

As I have said many times, I strongly support full, and rapid commercialization of space. And I believe that we can, and should get the full-cost recovery for all launch services the governmemt provides.

There are already new and highly imaginative areas of space rapidly moving toward commercial success. For example, the McDonnell Douglas Astronautics Company Electrophoresis process shows dramatic promise for both commercial success and for the potential of alleviating a major medical threat to mankind.

While SSI is not here today, they have found an imaginative niche for their company in space with their "cremains" satellite. Had someone gone to NASA with such a proposal they would have been laughed out the door. But SSI has found a potential what could potentially be a $30 million market, and those are earnings they can bank.

I am particularly concerned that we protect the potential for future investment in space materials processing. The McDAC testimony today indicates that a corporation which has already made significant investment in space processing has already written five of eleven highly promising processes off due to price increases, and will write off two more if the price raises get too high.

Mr. NELSON. The meeting of the subcommittee will come to order.

Delighted to see all of you. Seems like there's some interest in this subject matter today.

We're beginning the first of 2 days of hearings on the subject of the shuttle pricing policy. At issue is what price should commercial and foreign customers be charged for shuttle launches in the 1989-91 time period.

The ultimate answer to this questions will likely have a major impact on both the expendable launch vehicle community and the space user community. Accordingly, the purpose of today's hearing is to receive testimony from representatives of these two communities to determine what would be the likely impacts of different shuttle pricing policies on their respective business ventures.

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The members of the users panel are drawn from four different segments of the user community. First, from the Communications Satellite Builders and Operators segment we will hear from Dr. Robert Roney, vice president of the space and communications group of Hughes Aircraft, and Mr. Michael Lyons, vice president and general manager for space resources of Satellite Business Systems.

Then second, from the Upper Stage manufacturers segment of the community we will hear from Mr. Charles Ordahl, vice president of space programs of McDonnel Douglas and Mr. David Thompson, president of the Orbital Sciences Corp.

Third then, from the space platform builders and operators segment we will hear from Dr. John Townsend, president of the Fairchild Space Co.

And last, from the segment of the community that is undertaking materials processing in space initiatives, we will hear from Mr. James Rose, director for electrophoresis operations in space from McDonnell Douglas.

So, I would like to thank all of you for being present on this most important topic and I'm looking forward to the testimony that we're going to take, and I would like to recognize the ranking Republican member of this subcommittee, Mr. Walker, for an opening statement.

Mr. WALKER. Thank you, Mr. Chairman. Good afternoon. I'd like to join with you in welcoming our witnesses.

This afternoon we begin to address the most crucial issue in space policy for the remainder of this century.

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It is obvious that the space shuttle is the cornerstone of the space station and spacelab facilities where most of the processing will occur. I now believe that NASA has not been vigorous enough in aggressively pursuing private and foreign investors to fund a fifth orbiter and beyond. In the end I believe we will have to spin off the shuttle to either a quasi-governmental agency or some private operator to protect NASA from seeing other programs being strangled by shuttle operations.

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I am particularly concerned that we protect the potential for future investment in space materials processing. The McDAC testimony today indicates that a corporation which has already made significant investment in space processing has already written 5 of 11 highly promising processes off due to price increases, and will write off 2 more if the price raises get too high.

I think that that is the kind of issue that we have to address here. We have got to make some decisions that will certainly affect the rest of this century and beyond.

And, Mr. Chairman, I would also ask unanimous consent for an opening statement by the ranking member of the full committee, Mr. Lujan.

Mr. NELSON. Without objection.

[The prepared opening statement of Mr. Lujan follows:]

OPENING STATEMENT OF HON. MANUEL LUJAN, JR., A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW MEXICO

Thank you, Mr. Chairman.

What we are doing in this room today is of vital importance to the future of our nation in space. The question of shuttle pricing policy (and the ensuing policy decisions we will make) will prove to be of critical importance to our country's ability to retain a world leadership role in space in the years ahead. Unless we can provide cheap and reliable transportation to and from space, we will surely cripple our fledgling space commercialization effort. Of that, there can be no question. What is not clear right now is the appropriate balance of the federal government interests and private sector interests.

On the issue of shuttle pricing policy, the two camps are very well defined, with the customer caught smack in the middle.

On the one hand, the private sector—and specifically those companies interested in providing commercial launch services—simply can't compete in the launch services marketplace with the space shuttle. The private sector just can't beat the price of a space transportation system heavily subsidized—as even Mr. Beggs has admitted—by the federal government. President Reagan said last year in his State of the Union message that we would promote the commercialization of expendable launch vehicles. Some have interpreted this to mean that the shuttle should go to full operational cost recovery now, to give the commercial ELV industry a chance to compete in the marketplace. For a nation founded on the free enterprise system, this seems like a reasonable course of action.

On the other hand, we cannot forget that the space shuttle—or the space transportation system—is a system in which we have invested, over the years, close to $15 billion. The world's first reusable space transportation system, it has made us the envy of our friends and foes alike. Should we, in the name of "free enterprise", force shuttle prices up high enough to be competitive with yesterday's expendable launch vehicle technology? Many believe that true full cost recovery for the shuttle would simply drive the users of launch services across the sea, right into the arms of our competitors. Their case is also compelling and utterly reasonable.

A third solution, which is not openly discussed but seems to be covertly practiced, is simply to play with the numbers a little. You can, in this case, solve the policy dilemma by simply declaring a low enough figure for "full cost recovery" to keep the launch business in America. This is back-door problem solving and does not resolve the policy issue—it merely decides the sticky practical question of how much to charge a customer for a launch. The policy issue of what role the private sector should play in space and what role the federal government should play in space in the late 1980s and 1990s remains utterly unresolved.

In the case of commercial expendable launch vehicles and shuttle pricing policy we are firmly perched on the horns of a dilemma which pits the principles of private enterprise against the enormous investment we have made in our most valuable national space resource, the space transportation system. And, the fact is that we are going to sit on the horns of this dilemma—which is, take it from me, a very uncomfortable place to be—until we have the nerve to sit down and make some very difficult decisions. The critical question—and just about the only real issue in this debate—is this: precisely what is the role of the private sector in space and what is the proper role of the federal government?

Once we determine what the appropriate role of the federal government should be, then resolution of the shuttle pricing policy issue becomes easy. I hope that today's hearing will help us resolve this issue with the foresight needed to guarantee that America retains her role as a world leader in the space arena.

Mr. NELSON. OK, let's start. Mr. Savoca, we'd be delighted to hear from you.

STATEMENT OF ANTONIO L. SAVOCA, PRESIDENT AND CHIEF EXECUTIVE OFFICER OF TRANSPACE CARRIERS, INC., ACCOMPANIED BY DAVID W. GRIMES, CHAIRMAN AND CHIEF TECHNICAL OFFICER OF TRANSPACE CARRIERS, INC.

Mr. SAVOCA. Mr. Chairman and distinguished members of the subcommittee, I am Antonio L. Savoca, president and chief executive officer of Transpace Carriers, Inc. Seated with me, on my right, is David W. Grimes, chairman and chief technical officer of Transpace Carriers, Inc.

We greatly appreciate the opportunity to address the subcommittee on the impact that the NASA recommended shuttle price for fiscal years 1989 and beyond will have on our emerging industry.

We are staunch proponents of the manned space shuttle. Many members of TCI management, myself included, worked on the program. This program ranks very high among man's accomplishments.

However, in order to implement the national policy that is now opening up the gates to commercial activities in space, all participants must compete in an evenhanded way for commercial sector payloads. The rational commercialization of space requires NASA to price its services for commercial and foreign users at the same full cost that commercial launch providers must charge. We do not believe the current pricing proposal does so.

Our company was incorporated in September 1982 to——

Mr. NELSON. Let me interrupt you just 1 second. We've got a bunch of people that don't have any seats here. You all want to come on and sit right in here. If there are no empty seats out there come on and help yourselves to these seats right here.

All of the rest of you—and I'd like you to shut that door. If it gets too hot we'll open it back up, but there's a lot of noise out there. The rest of you standing, you're welcome to come over here and have a seat. There are several other seats left.

All right, please.

Mr. SAVOCA. Thank you.

Our company was incorporated in September 1982 to transition the delta launch vehicle to the private sector. We followed the procurement procedures set up by NASA for this activity, which culminated in an agreement between NASA and ourselves, reviewed and approved by the House and Senate committees and executed by NASA on May 16, 1984.

We have assembled an outstanding senior management team with considerable experience in the aerospace industry. The combined experience level of these top five individuals is 146 years, of which 98 were specifically associated with the U.S. space program.

Mr. Grimes was with NASA for 19 years, serving the last 5 years as manager of the Delta program that we are talking about.

Prior to joining TCI, I served for more than 8 years as senior vice president, Morton Thiokol Corp., and general manager of its Wasatch Division, which among other propulsion programs included responsibility for design, development, and production of the space shuttle solid rocket motors.

George Page, vice president of operations has 33 years of aerospace engineering and operations experience, including 27 years of space launch operations, 21 of which have been with NASA in positions such as Deputy Director of Kennedy Space Center, director of shuttle operations for the first four shuttle missions, director of expendable launch vehicle operations, and manager of Apollo spacecraft operations.

Herbert Balzuweit, vice president, finance and administraction, spent 8 years with GTE Corp. in various positions of increasing responsibility, both domestic and abroad. During the last 4 years at GTE, Mr. Balzuweit was vice president, controller of GTE Telenet Communications Corp.

Jack Pinto, vice president of marketing, has 30 years of engineering and marketing experience and was with IBM Corp. for 23 years. Most recently, he served as director of marketing, Owego Operations.

We have negotiated major hardware supplier contracts with McDonnell Douglas Corp. and Morton Thiokol. We are in the final stages of completing our negotiations with Rockwell Corp. We are working with First Boston Corp., who has agreed to raise the substantial capital required to start and sustain the production activity until cash flow from sales can sustain it. Success in the financial market is heavily dependent on unsubsidized Government competition.

In addition, Bank of America has provided a $15 million line of credit for TCI against contracts, and has agreed to provide a $35 million customer financing package wherein a credit-worthy customer can finance his launch on a 7-year program with payments deferred to the last 5 years.

The President's policy on commercialization of ELV's preceded TCI's agreement with NASA by exactly 1 year, May 16, 1983. This policy specifically stated that,

> The U.S. Government fully endorses and will facilitate the commercialization of U.S. expendable launch vehicles.

The policy also stated that beginning in fiscal year 1989,

> It is the U.S. Government's intent to establish a full-cost recovery policy for commercial and foreign STS flight operations.

Full-cost recovery for STS pricing is certainly consistent with the goals of the overall policy to establish a commercial launch vehicle industry in the United States. A commercial launch vehicle industry cannot exist if it has Government competition that does not face the same economic world. The $87 million STS price in 1982 dollars, recommended by NASA, falls substantially short of full-cost recovery as that term is known in the economic world. Indeed, given the apparent NASA definition, no rational businessman would decide to enter the industry.

If it is left to stand, the $87 million price for STS would cause the emerging expendable launch vehicle industry to fail. If TCI were to fail for this reason, the millions of dollars of investor capital that have sustained us thus far would have been lost without the company ever having had a chance to succeed in the marketplace.

The extent of the deviations from full cost can be demonstrated easily and I'd like you to examine a chart that we have prepared. I'm going to move over to the screen and I'll speak loudly.

There are many figures on this chart. We won't talk about all of them, but it's necessary for the explanation to have them there. What we have done is we have taken data directly from the September 17 NASA submittal to the President on which this chart is based.

All of the dollars on the chart are in 1982 dollars so they are constant 1982 dollars. In columns No. 1 and 2, are unit dollars and the unit is one STS flight; unit dollars for NASA hardware budget and unit dollars for NASA operations budget. Column No. 3 are flights planned from the submittal, aginst which NASA based this price. Column No. 4 is TCI's estimate of the flights that NASA might achieve during this time period and we differ from NASA there wherein we say during the critical years we are talking about, and those are the 3 years bounded by the horizontal lines here, we think NASA will average, on the high side, 16 flights, versus the 24 that they say they will average.

This comes from experience that we have with the shuttle program, mine and George Page's and other management of TCI, and then, of course, it was George Page's job to assess the flight capability of Kennedy, during the time that he was in operation there.

Now, column No. 5 is merely an addition of columns No. 1 and 2, NASA's hardware budget and operations budget, and then here's a cost per flight that you see there. Circled are the three numbers that NASA came up with for these 3 years and they said, "we will adjust those numbers upward in the event that there was any omission that we had and will adjust them upward to $87 million." That's where the $87 million comes from.

Then column No. 6 is our revision for the lower flight record and basically what we did there was a very, very simple calculation of taking the amount of No. 1 without question and then taking column No. 2, multiplying it by column No. 3, NASA's flight rate, and dividing it by column No. 4, our flight rate, and that adjustment then appears in these three numbers here.

Then NASA did not amortize orbiter costs in their price any at all and so we said an orbiter must cost at least $1.5 billion. I think the estimate is closer to $2 billion, but we said at least a billion and a half, and we will take the design life of the orbiter of 100 flights and base that figure on, and so we divided a hundred into a billion and a half and there should be an amortization charge of at least $15 million for the orbiter per flight.

Then column No. 8 is the cost of money and for the cost of money we used the instructions in OMB's circular A94 and that says to use constant dollars. Use a 10-percent rate, and we did that against the cost of the orbiters only, and we did that against the cost of only three orbiters, rather than four; we said that one orbiter could be a research and development orbiter and we wouldn't count that in there at all.

So, when you do the cost of money on that basis, it adds these amounts to the cost per flight.

Then there was no cost in the calculation for insurance for the orbiter and so, we used a 2-percent rate per flight, for orbiter insurance. If you discuss this with space brokers, some space brokers will say that the going cost would be at least 8 percent per flight, so 2 percent of $1.5 billion is $30 million and that's the number that appears there.

And then finally, column No. 10, we adjusted for a more appropriate learning curve on hardware labor and NASA used an 80- to 88-percent learning curve for hardware labor, more industrially acceptable over this period of time, for this type of activity, is a 93-percent learning curve. When you make that adjustment, that adds these dollars into the calculation.

So, if you then include only those items, you come up with a cost per flight that averages $188 million versus the $87 million that NASA has estimated as a true cost recovery.

Now, this also has some gross omissions to it that we did not include because we had no way of scoping those omissions. And those are that there are no dollars in there for research and development to sustain the activity from this point forward, not going back to recoup research and development, but from this point forward only. There is no offset there for taxes, which commercial ELV's have to pay, and there's no offset for return on investment, which commercial ELV's have to earn. There is—there are no dollars we can see in there for facilities to make the launch rate that NASA is talking about.

And then finally, we think that the operations budget is grossly overstated and you can see how we come to that conclusion if you take the unit operations budget for 1984, multiply it by column three flight rate, you get an operations budget of $1.1 billion at the eight flight rate. If you go to the first time NASA reaches 24 flights and multiply $39.1 million times the 24 flights, you get a budget of $938 million, so really what that says is that the flight rates will triple and the operations budget will decrease, and industrially that doesn't seem possible.

Now, the final thing that I want to say about pricing is that when NASA operated the Delta program and sold launches commercially to commercial and foreign customers for the Delta program, they used an existing NASA policy to do that pricing, which recovered full cost for Delta, and, as a matter of fact, there was an after-the-year accounting adjustment, so if costs were more than what were charged, why they were allocated to the users that covered those charges. The only two things that were not covered by that policy was offset for taxes and return on investement, and the reason those were not covered is that there was no commercial ELV industry in being at that time and it was not necessary to cover those.

If the U.S. Government is to be in competition with the commercial expendable launch vehicle industry, then the United States must charge commercial users all costs that commercial companies must charge. If this is not done, the United States will drive out of business the industry it has encouraged to develop. Certainly, a question to consider is whether or not it is in keeping with the economic objectives of a free economy to have Government compete with private industry at all. TCI strongly believes that full commercial cost recovery is the only economically sound policy for a free-market nation to follow.

Another factor in the expendable launch vehicle economic world is the foreign government competition, Ariane. Ariane has maintained a two-tier pricing structure, wherein they charge ESA nations a much higher price than launches sold in the United States and outside the ESA nations. This has been freely admitted by Mr. F. D'Allest, in many fora, including testimony before the Senate Subcommittee on Space in December of 1982.

Since Transpace Carriers entered the marketplace, Ariane has subsidized its prices to an even greater extent. Before TCI, Ariane charged a subsidized price of about $25 million per Delta class payload, while charging about $32 million to the ESA nations. We have now seen prices in the $19 to $20 million range outside the ESA nations.

On May 25, 1984, we submitted a petition to the U.S. Trade Representative seeking to bring an end to the ESA nations subsidy of the Ariane system. The USTR has begun consultations with ESA and is scheduled to make its recommendation for Presidential action no later than early July of this year. During these consultations, it is our understanding that ESA has again stated the position that they would like to end their subsidy if NASA would go to an unsubsidized price for the STS.

There are several arguments being advanced for continuing less than full cost recovery STS prices. None of the arguments are sound.

Some allege that Delta is old technology. In fact, the U.S. ELV's have been consistently upgraded and enhanced by NASA in order to assure the use of state-of-the-art technology in both launch and ground systems.

It has been alleged that the market is too small to support commercial ELV's and the space shuttle. Communications satellite usage worldwide is increasing providing ample business opportunities for U.S. ELV's. During this period of expansion, the space shuttle will be the only manned reusable launch system to support the space station and most of the space industry. The Center for Space Policy estimates the revenue for space industries as exceeding $60 billion by the year 2000. NASA's 1990 and 1991 planning for commercial and foreign satellites equates to a forecast of 28 equivalent Delta class payloads, which conforms to our own estimate.

It has also been alleged that full cost will result in Ariane capturing the entire marketplace. This assumes that U.S. ELV's will not be competitive on a level playing field, which the 301 proceeding is intended to obtain and overlooks the Ariane operational limitations.

Another alleged result of shuttle full-cost recovery is that the high cost of launch will drive users from satellites to fiber optics. A recent Intelsat analysis indicates that satellites, in addition to providing multipoint capability also provide, on a per circuit basis, a 30- to 70-percent cost advantage.

Another argument often heard against full-cost recovery is that it will cause potential space technology investors and developers to rethink these investments. The Presidential policy directs full-cost recovery for only commercial and foreign STS flight operations and allows for subsidized prices for research and development activities. This was emphasized by the Science Adviser to the President in his October 1984 letter in response to Senator Gorton's letter of August 31, 1984, regarding STS R&D prices.

One last argument against full-cost recovery often advanced is that it would make the upper stages deployed from the shuttle noncompetitive. No upper stage, however, should depend on a subsidy of its low-earth orbit transportation in order to be economically viable. Charging commercial full cost for shuttle services should not affect upper stage—expendable upper stage providers, since they would compete on the merits and costs of services they provide using shuttle priced on a level playing field.

In summary, Transpace Carriers would like to compete in a free market economy consistent with the tradition of this Nation. We entered this business relying on the STS going to full-cost recovery in fiscal year 1989. We believed that the ESA nations were weary of their subsidy and would follow the STS price up. If they did not, we were prepared to file a 301 petition. We filed the petition early—earlier than we had anticipated because they drastically reduced their price coincident with our agreement with NASA to transition Delta to the private sector.

The structure of the space launch industry providing transportation to the 22,300 mile transfer orbit now contains: (1) Companies which are totally commercial, Transpace Carriers and General Dynamics, who must recover their entire cost plus a return on investment for the entire trip; (2) A quasi-private company, Arianespace, which is about 60 percent owned by France and is subsidized by the ESA member nations; and (3) Private upper stage companies, McDonnell Douglas, Orbital Sciences, and others, which utilize the Government-subsidized shuttle for what is essentially the first and second stages of their operations. Government subsidy in any part of this structure distorts the operation of a free economy, resulting in a misallocation of resources. These subsidies will ensure the failure of the truly private companies, who are not dependent upon U.S. Government subsidy. Failure to permit an economically sound environment for the commercialization of U.S. ELV's would be the effective elimination of the two most reliable launch vehicles in the world and the forfeiture of this growing market and technology to foreign interests which are pursuing development and production of ELV's.

On the other hand, successful commercialization of U.S. ELV's can provide the United States with a continued leadership position in this segment of space launch services, technical capability will be preserved for the United States, and new ELV innovation will occur stimulated by market demand. Balance of payments will be enhanced, U.S. launch backup to the STS for ELV class payloads will remain in place, and emergency systems for many military launches will be available if and when needed. Finally, the financial community, now skittist of capital investment in space, will obtain a positive signal from the Government's implementation of its stated full-cost recovery policy for shuttle that the U.S. Government is serious in its intent to open up space commercially as other opportunities mature.

Thank you, Mr. Chairman. We will be happy to answer any questions.

[The prepared statement of Mr. Savoca follows:]

PREPARED STATEMENT OF ANTONIO L. SAVOCA

MR. CHAIRMAN AND DISTINGUISHED MEMBERS OF THE SUBCOMMITTEE: I AM ANTONIO L. SAVOCA, PRESIDENT AND CHIEF EXECUTIVE OFFICER OF TRANSPACE CARRIERS, INCORPORATED. SEATED WITH ME IS DAVID W. GRIMES, CHAIRMAN AND CHIEF TECHNICAL OFFICER OF TRANSPACE CARRIERS, INC.

WE GREATLY APPRECIATE THE OPPORTUNITY TO ADDRESS THE SUBCOMMITTEE ON THE IMPACT THAT THE NASA RECOMMENDED SHUTTLE PRICE FOR FISCAL YEARS 1989 AND BEYOND WILL HAVE ON OUR EMERGING INDUSTRY.

WE ARE STAUNCH PROPONENTS OF THE MANNED SPACE SHUTTLE. MANY MEMBERS OF TCI MANAGEMENT, MYSELF INCLUDED, WORKED ON THE PROGRAM. THIS PROGRAM RANKS VERY HIGH AMONG MAN'S ACCOMPLISHMENTS.

HOWEVER, IN ORDER TO IMPLEMENT THE NATIONAL POLICY THAT IS NOW OPENING UP THE GATES TO COMMERCIAL ACTIVITIES IN SPACE, ALL PARTICIPANTS MUST COMPETE IN AN EVEN HANDED WAY FOR COMMERCIAL SECTOR PAYLOADS. THE RATIONAL COMMERCIALIZATION OF SPACE REQUIRES NASA TO PRICE ITS SERVICES FOR COMMERCIAL AND FOREIGN USERS AT THE SAME FULL COST THAT COMMERCIAL LAUNCH PROVIDERS MUST CHARGE. WE DO NOT BELIEVE THAT NASA'S PRICING PROPOSAL DOES SO.

OUR COMPANY WAS INCORPORATED IN SEPTEMBER 1982 TO TRANSITION THE DELTA LAUNCH VEHICLE TO THE PRIVATE SECTOR. WE FOLLOWED THE PROCUREMENT PROCEDURES SET UP BY NASA FOR THIS ACTIVITY WHICH CULMINATED IN AN AGREEMENT BETWEEN NASA AND OURSELVES, REVIEWED AND APPROVED BY THE HOUSE AND SENATE COMMITTEES, AND EXECUTED BY NASA ON 16 MAY 1984. LEGISLATION WAS PASSED IN NOVEMBER, 1984.

MANAGEMENT

TCI HAS ASSEMBLED AN OUTSTANDING SENIOR MANAGEMENT TEAM WITH CONSIDERABLE EXPERIENCE IN THE AEROSPACE INDUSTRY. THE COMBINED EXPERIENCE LEVEL OF THESE FIVE INDIVIDUALS IS 146 YEARS OF WHICH 98 WERE SPECIFICALLY ASSOCIATED WITH THE U.S. SPACE PROGRAM. ~~THEY INCLUDE~~:

MR. GRIMES WAS WITH NASA FOR 19 YEARS, SERVING THE LAST FIVE YEARS AS ~~PROJECT~~ MANAGER, DELTA LAUNCH VEHICLE PROGRAM.

PRIOR TO JOINING TCI I SERVED FOR MORE THAN EIGHT YEARS AS SENIOR VICE PRESIDENT, MORTON THIOKOL CORPORATION, AND GENERAL MANAGER, WASATCH DIVISION, WHICH AMONG OTHER PROPULSION PROGRAMS INCLUDED RESPONSIBILITY FOR DESIGN, DEVELOPMENT AND PRODUCTION OF THE SPACE SHUTTLE SOLID ROCKET MOTORS.

GEORGE F. PAGE, VICE PRESIDENT, OPERATIONS. HAS 33 YEARS OF AEROSPACE ENGINEERING AND OPERATIONS EXPERIENCE, INCLUDING 27 YEARS OF SPACE LAUNCH OPERATIONS, 21 OF WHICH HAVE BEEN WITH NASA IN POSITIONS SUCH AS DEPUTY DIRECTOR OF KENNEDY SPACE CENTER, DIRECTOR OF SHUTTLE OPERATIONS FOR THE FIRST FOUR SHUTTLE MISSIONS, DIRECTOR OF EXPENDABLE LAUNCH VEHICLE OPERATIONS, AND MANAGER OF APOLLO SPACECRAFT OPERATIONS.

HERBERT F. BALZUWEIT, VICE PRESIDENT, FINANCE AND ADMINISTRATION. HE SPENT EIGHT YEARS WITH GTE CORPORATION IN VARIOUS POSITIONS OF INCREASING RESPONSIBILITIES, BOTH DOMESTIC AND ABROAD. DURING THE LAST FOUR YEARS AT GTE, MR. BALZUWEIT WAS VICE PRESIDENT, CONTROLLER OF GTE TELENET COMMUNICATIONS CORPORATION.

JACK W. PINTO, VICE PRESIDENT, MARKETING. HAS 30 YEARS OF ENGINEERING AND MARKETING ~~AEROSPACE~~ EXPERIENCE AND WAS WITH IBM CORPORATION FOR 23 YEARS. MOST RECENTLY HE SERVED AS DIRECTOR OF MARKETING, OWEGO OPERATIONS.

TCI STATUS

WE HAVE NEGOTIATED MAJOR HARDWARE SUPPLIER CONTRACTS WITH MCDONNELL DOUGLAS, AND MORTON THIOKOL. WE ARE IN THE FINAL

STAGES OF COMPLETING OUR NEGOTIATION WITH ROCKWELL CORPORATION. WE ARE WORKING WITH FIRST BOSTON CORPORATION WHO HAS AGREED TO RAISE THE SUBSTANTIAL CAPITAL REQUIRED TO START AND SUSTAIN THE PRODUCTION ACTIVITY UNTIL CASH FLOW FROM SALES CAN SUSTAIN IT. SUCCESS IN THE FINANCIAL MARKET IS HEAVILY DEPENDENT ON UNSUBSIDIZED GOVERNMENT COMPETITION.

IN ADDITION, BANK OF AMERICA HAS AGREED TO A $15,000,000 LINE OF CREDIT FOR TCI AGAINST CONTRACTS. BANK OF AMERICA IS WILLING TO PROVIDE A $35,000,000 CUSTOMER FINANCING PACKAGE WHEREIN A CREDIT WORTHY CUSTOMER CAN FINANCE HIS LAUNCH ON A SEVEN YEAR PROGRAM WITH PAYMENTS DEFERRED TO THE LAST FIVE YEARS.

STS PRICING

THE PRESIDENT~~IAL~~ POLICY ON COMMERCIALIZATION OF ELV'S PRECEDED TCI'S AGREEMENT WITH NASA BY EXACTLY ONE YEAR - 16 MAY 1983. THIS POLICY SPECIFICALLY STATED THAT

> "THE U.S. GOVERNMENT FULLY ENDORSES AND WILL FACILITATE THE COMMERCIALIZATION OF U.S. EXPENDABLE LAUNCH VEHICLES."

THE POLICY ALSO STATED THAT BEGINNING IN FY 1989

> "IT IS THE U.S. GOVERNMENT'S INTENT TO ESTABLISH A FULL COST RECOVERY POLICY FOR COMMERCIAL AND FOREIGN STS FLIGHT OPERATIONS."

FULL COST RECOVERY FOR STS PRICING IS CERTAINLY CONSISTENT WITH THE GOALS OF THE OVERALL POLICY TO ESTABLISH A COMMERCIAL LAUNCH VEHICLE INDUSTRY IN THE UNITED STATES. A COMMERCIAL CLV INDUSTRY CANNOT EXIST IF IT HAS GOVERNMENT COMPETITION THAT DOES NOT FACE THE SAME ECONOMIC WORLD. THE $87 MILLION STS PRICE IN 1982 DOLLARS RECOMMENDED BY NASA FALLS SUBSTANTIALLY SHORT OF FULL-COST-RECOVERY AS THE TERM IS KNOWN IN THE ECONOMIC WORLD. INDEED, GIVEN THE APPARENT NASA DEFINITION, NO RATIONAL BUSINESSMAN WOULD DECIDE TO ENTER THE INDUSTRY.

IF IT IS LEFT TO STAND, THE $87 MILLION PRICE FOR STS WOULD CAUSE THE EMERGING EXPENDABLE LAUNCH VEHICLE INDUSTRY TO FAIL. IF TCI WERE TO FAIL FOR THIS REASON, THE MILLIONS OF DOLLARS OF INVESTOR CAPITAL THAT HAS SUSTAINED US THUS FAR WOULD HAVE BEEN LOST WITHOUT THE COMPANY EVER HAVING HAD A CHANCE TO SUCCEED IN THE MARKETPLACE.

THE EXTENT OF THE DEVIATIONS FROM FULL COST CAN BE DEMONSTRATED EASILY. PLEASE EXAMINE THE CHART WE HAVE PREPARED. A MORE DETAILED COPY OF THE CHART IS ATTACHED FOR THE

RECORD. ALL OF THE AMOUNTS ON THE CHART ARE IN 1982 DOLLARS AND ARE PER UNIT NUMBERS WITH THE UNIT BEING ONE STS PAYLOAD BAY. WE USED THE DATA IN THE NASA RECOMMENDATION TO THE PRESIDENT AS A BASELINE AND ADJUSTED IT FOR KNOWN OMISSIONS THAT COULD BE READILY QUANTIFIED. COLUMN 1 IS HARDWARE COST AND COLUMN 2 IS THE PER UNIT OPERATIONS BUDGET. COLUMN 3 IS NASA'S RECOMMENDED FLIGHT RATES PER YEAR. BASED UPON NASA'S PAST ACCOMPLISHMENTS AND FACILITIES LIMITATIONS COLUMN 4 IS THE RATE WE BELIEVE NASA MAY ACHIEVE ON THE HIGH SIDE. COLUMN 5 IS THE SUM OF COLUMNS 1 AND 2 AND, IN THE THREE YEARS BOUNDED BY THE HORIZONTAL LINES, IS NASA'S RECOMMENDED PAYLOAD BAY CALCULATION FOR FY '89, '90, AND '91 OF $83.9, $83.6, AND $82.5 MILLION WHICH THE AGENCY ADJUSTED UP TO AN AVERAGE OF $87 MILLION. COLUMN 6 APPLIES OUR CORRECTION FOR THE LOWER FLIGHT RATE WHICH WE CALCULATED BY TAKING COLUMN 1 AND ADDING TO THAT THE SUM OF COLUMN 2 TIMES COLUMN 3, DIVIDED BY COLUMN 4. COLUMN 7 IS ORBITER AMORTIZATION ARRIVED AT BY ASSUMING A LOW ORBITER COST OF $1.5 BILLION, DIVIDED BY THE 100 FLIGHT DESIGN LIFE PER ORBITER. AN INTERESTING SIDELIGHT OF THIS IS THAT IF WE AMORTIZE ONLY 3 OF THE 4 ORBITERS IN 1995, WHEN IT IS ESTIMATED BY NASA THAT THE STS WILL BE TRANSITIONED TO THE PRIVATE SECTOR, THERE WILL REMAIN A $2.25 BILLION UNAMORTIZED BALANCE FOR ORBITERS ALONE THAT WOULD HAVE TO BE RECOVERED IN THE COMMERCIALIZATION PROCESS. COLUMN 8 REPRESENTS THE COST OF MONEY COMPUTED AT 10% PER YEAR FOR 10 YEARS ON THE COST OF 3

ORBITERS ONLY. COLUMN 9 IS ORBITER INSURANCE COMPUTED AT A VERY LOW FIGURE OF 2% OF THE REPLACEMENT VALUE OF ONE ORBITER. COLUMN 10 IS A CORRECTION OF COLUMN 1 HARDWARE, LABOR ONLY, FOR A MORE REALISTIC LABOR LEARNING CURVE OF 93% RATHER THAN THE 80 - 88% CURVES IT APPEARS NASA USED. COLUMN 11 IS THE SUM OF COLUMNS 6 THRU 10 WHICH YIELDS AN AVERAGE PRICE OF $188 MILLION PER PAYLOAD BAY. THE EXPENDABLE LAUNCH VEHICLE INDUSTRY WOULD BE VIABLE AT $150 MILLION PAYLOAD BAY PRICE IN 1982 DOLLARS. THE $188 MILLION ESTIMATE STILL DOES NOT INCLUDE MANY ITEMS BECAUSE WE HAD NO WAY OF DETERMINING THE APPROPRIATE DOLLAR AMOUNT TO BE ADDED EVEN THOUGH THESE ADDITIONS WOULD REPRESENT SUBSTANTIAL COSTS. IT DOES NOT INCLUDE:

- DOLLARS FOR SUSTAINING R&D OR SYSTEM UPGRADES,
- OFFSET FOR TAXES WHICH COMMERCIAL ELV'S MUST PAY,
- OFFSET FOR RETURN ON INVESTMENT WHICH COMMERCIAL ELV'S MUST EARN,
- FACILITY OR EQUIPMENT COST INCLUDED TO MAKE THE HIGHER FLIGHT RATE,
- COST FOR NASA'S COMMERCIAL MARKETING EFFORT.

IN ADDITION TO THE ABOVE, EXPERIENCE INDICATES THAT THE OPERATIONS BASE IS OVER-OPTIMISTICALLY CALCULATED. THE OPERATIONS BASE (COL. 2 TIMES COL. 3) IN 1984 TOTALS $1.1B FOR 8 FLIGHTS. IT IS DOUBTFUL THAT THE OPERATIONS BASE CAN DECREASE IN 1989 TO APPROXIMATELY $.9B (COL. 2 TIMES COL. 3) WHILE TRIPLING THE FLIGHT RATE TO 24 LAUNCHES PER YEAR.

IF THE UNITED STATES GOVERNMENT IS TO BE IN COMPETITION WITH THE COMMERCIAL EXPENDABLE LAUNCH VEHICLE INDUSTRY, THEN THE UNITED STATES MUST CHARGE COMMERCIAL USERS ALL COSTS THAT COMMERCIAL COMPANIES MUST CHARGE. IF THIS IS NOT DONE, THE UNITED STATES WILL DRIVE OUT OF BUSINESS THE INDUSTRY IT HAS ENCOURAGED TO DEVELOP. CERTAINLY, A QUESTION TO CONSIDER IS WHETHER NOR NOT IT IS IN KEEPING WITH THE ECONOMIC OBJECTIVES OF A FREE ECONOMY TO HAVE GOVERNMENT COMPETE WITH PRIVATE INDUSTRY AT ALL? ICD STRONGLY BELIEVES THAT FULL COMMERCIAL COST RECOVERY IS THE ONLY ECONOMICALLY SOUND POLICY FOR A FREE MARKET NATION TO FOLLOW.

ARIANE AND 301 FILING

ANOTHER FACTOR IN THE EXPENDABLE LAUNCH VEHICLE ECONOMIC WORLD IS THE FOREIGN GOVERNMENT COMPETITION ARIANE. ARIANE HAS MAINTAINED A TWO TIER PRICING STRUCTURE WHEREIN THEY CHARGE ESA NATIONS A MUCH HIGHER PRICE THAN LAUNCHES SOLD IN THE UNITED STATES AND OUTSIDE THE ESA NATIONS. THIS HAS BEEN FREELY ADMITTED BY MR. F. D'ALLEST, INCLUDING TESTIMONY BEFORE THE SENATE SUBCOMMITTEE ON SPACE.

SINCE TRANSPACE CARRIERS ENTERED THE MARKETPLACE, ARIANE HAS BEEN DROPPING ITS SUBSIDIZED PRICES TO AN EVEN GREATER EXTENT. BEFORE TCI, ARIANE CHARGED A SUBSIDIZED PRICE OF

ABOUT $25 MILLION PER DELTA CLASS PAYLOAD WHILE CHARGING ABOUT $32 MILLION TO THE ESA NATIONS. WE HAVE NOT SEEN PRICES IN THE $19-20 MILLION RANGE OUTSIDE THE ESA NATIONS.

ON MAY 25, 1984, WE SUBMITTED A PETITION TO THE UNITED STATES TRADE REPRESENTATIVE SEEKING TO BRING AN END TO THE ESA NATIONS SUBSIDY OF THE ARIANE SYSTEM. USTR HAS BEGUN CONSULTATIONS WITH ESA AND THE TRADE REPRESENTATIVE IS SCHEDULED TO MAKE HIS RECOMMENDATION FOR PRESIDENTIAL ACTION NO LATER THAN EARLY JULY OF THIS YEAR. DURING THESE CONSULTATIONS, IT IS OUR UNDERSTANDING THAT ESA HAS AGAIN STATED THE POSITION THAT THEY WOULD LIKE TO END THEIR SUBSIDY IF NASA WOULD GO TO AN UNSUBSIDIZED PRICE FOR STS.

RESPONSE TO ALLEGATIONS

WE BELIEVE THE ARGUMENTS ADVANCED FOR CONTINUING LESS THAN FULL COST RECOVERY STS PRICES ARE NOT SOUND.

SOME ALLEGE THAT DELTA IS OLD TECHNOLOGY. IN FACT, THE U.S. ELVS HAVE BEEN CONSISTENTLY UPGRADED AND ENHANCED BY NASA IN ORDER TO ASSURE THE USE OF STATE OF THE ART TECHNOLOGY IN LAUNCH SYSTEMS AND GROUND SYSTEMS.

IT HAS BEEN ALLEGED THAT THE MARKET IS TOO SMALL TO SUPPORT COMMERCIAL ELVS AND THE SPACE SHUTTLE. COMMUNICATIONS SATELLITE USAGE WORLDWIDE IS INCREASING, PROVIDING BUSINESS OPPORTUNITIES FOR U.S. ELVS. DURING THAT TIME, THE SPACE SHUTTLE WILL BE THE ONLY MANNED REUSABLE LAUNCH SYSTEM TO SUPPORT THE SPACE STATION AND MOST OF THE SPACE INDUSTRIES. THE CENTER FOR SPACE POLICY ESTIMATES THE REVENUE FOR SPACE INDUSTRIES AS EXCEEDING $60 BILLION BY THE YEAR 2000. NASA'S 1990 AND 1991 PLANNING FOR COMMERCIAL AND FOREIGN SATELLITES EQUATES TO A FORECAST 28 EQUIVALENT DELTA CLASS PAYLOADS.

IT HAS ALSO BEEN ALLEGED THAT FULL COST WILL RESULT IN ARIANE CAPTURING THE ENTIRE MARKETPLACE. THIS ASSUMES THAT U.S. ELVS WILL NOT BE COMPETITIVE ON A LEVEL PLAYING FIELD WHICH THE 301 PROCEEDING IS INTENDED TO OBTAIN AND OVERLOOKS THE ARIANE OPERATIONAL LIMITATIONS.

ANOTHER ALLEGED RESULT OF SHUTTLE FULL COST RECOVERY IS THAT THE HIGH COST OF LAUNCH WILL DRIVE USERS FROM SATELLITES TO FIBER OPTICS SYSTEMS. A RECENT INTELSAT ANALYSIS INDICATES THAT SATELLITES IN ADDITION TO PROVIDING MULTIPOINT CAPABILITY ALSO PROVIDE ON A PER CIRCUIT BASIS A 30 TO 70% COST SAVINGS.

ANOTHER ARGUMENT OFTEN HEARD AGAINST FULL COST RECOVERY IS THAT IT WILL CAUSE POTENTIAL SPACE TECHNOLOGY INVESTORS AND DEVELOPERS TO RETHINK THESE INVESTMENTS. THE PRESIDENTIAL POLICY DIRECTS FULL COST RECOVERY FOR ONLY COMMERCIAL AND FOREIGN STS FLIGHT OPERATIONS AND ALLOWS FOR SUBSIDIZED PRICES FOR RESEARCH AND DEVELOPMENT ACTIVITIES. THIS WAS EMPHASIZED BY THE SCIENCE ADVISOR TO THE PRESIDENT IN HIS OCTOBER 15, 1984, LETTER IN RESPONSE TO SENATOR GORTON'S LETTER OF AUGUST 31, 1984.

ONE LAST ARGUMENT AGAINST FULL COST RECOVERY OFTEN ADVANCED IS THAT IT WOULD MAKE THE UPPER STAGES DEPLOYED FROM THE SHUTTLE NON-COMPETITIVE. NO UPPER STAGE, HOWEVER, SHOULD DEPEND ON A SUBSIDY OF ITS LOW EARTH ORBIT TRANSPORTATION IN ORDER TO BE ECONOMICALLY VIABLE. CHARGING COMMERCIAL FULL COST FOR SHUTTLE SERVICES WOULD NOT AFFECT EXPENDABLE UPPER STAGE PROVIDERS SINCE THEY WOULD COMPETE ON THE MERITS AND COSTS OF SERVICES THEY PROVIDE USING SHUTTLE PRICED ON A LEVEL PLAYING FIELD.

SUMMARY

IN SUMMARY, TRANSPACE CARRIERS, INC. WOULD LIKE TO COMPETE IN A FREE MARKET ECONOMY CONSISTENT WITH THE TRADITION OF THIS NATION. WE ENTERED THIS BUSINESS RELYING ON THE STS

GOING TO FULL COST RECOVERY IN FY '89. WE BELIEVED THAT THE ESA NATIONS WERE WEARY OF THEIR SUBSIDY AND WOULD FOLLOW THE STS PRICE UP. IF THEY DID NOT, WE WERE PREPARED TO FILE A 301 PETITION. WE FILED THE PETITION EARLIER THAN WE HAD ORIGINALLY ANTICIPATED BECAUSE THEY DRASTICALLY REDUCED THEIR PRICE COINCIDENT WITH OUR SIGNED AGREEMENT WITH NASA TO TRANSITION DELTA TO THE PRIVATE SECTOR. THE STRUCTURE OF THE SPACE LAUNCH INDUSTRY PROVIDING TRANSPORTATION TO THE 22,300 MILE TRANSFER ORBIT NOW CONTAINS: (1) COMPANIES WHICH ARE TOTALLY COMMERCIAL, TRANSPACE CARRIERS AND GENERAL DYNAMICS, WHO MUST RECOVER THEIR ENTIRE COST PLUS A RETURN ON INVESTMENT FOR THE ENTIRE TRIP; (2) A QUASI-PRIVATE COMPANY, ARIANESPACE, WHICH IS 60% OWNED BY FRANCE AND IS SUBSIDIZED BY THE ESA MEMBER NATIONS; AND, (3) PRIVATE UPPER STAGE COMPANIES, MCDONNELL DOUGLAS, ORBITAL SCIENCES, AND OTHERS, WHICH UTILIZE. THE GOVERNMENT SUBSIDIZED SHUTTLE FOR WHAT IS ESSENTIALLY THE FIRST AND SECOND STAGES OF THEIR OPERATION. GOVERNMENT SUBSIDY IN ANY PART OF THIS STRUCTURE DISTORTS THE OPERATION OF A FREE ECONOMY RESULTING IN A MISALLOCATION OF RESOURCES. THESE SUBSIDIES WILL ENSURE THE FAILURE OF THE TRULY PRIVATE COMPANIES WHO ARE NOT DEPENDENT UPON GOVERNMENT SUBSIDY. FAILURE TO PERMIT AN ECONOMICALLY SOUND ENVIRONMENT FOR THE COMMERCIALIZATION OF U.S. ELVS WOULD BE THE EFFECTIVE ELIMINATION OF THE TWO MOST RELIABLE LAUNCH VEHICLES IN THE WORLD AND THE FORFEITURE OF THIS

GROWING MARKET AND TECHNOLOGY TO FOREIGN INTERESTS WHICH ARE PURSUING DEVELOPMENT AND PRODUCTION OF ELVS.

ON THE OTHER HAND, SUCCESSFUL COMMERCIALIZATION OF U.S. ELVS CAN PROVIDE THE U.S. WITH A CONTINUED LEADERSHIP POSITION IN THIS SEGMENT OF SPACE LAUNCH SERVICES, TECHNICAL CAPABILITY WILL BE PRESERVED FOR THE UNITED STATES, AND NEW ELV INNOVATION WILL OCCUR STIMULATED BY MARKET DEMAND. BALANCE OF PAYMENTS WILL BE ENHANCED, U.S. LAUNCH BACK-UP TO THE STS FOR ELV CLASS PAYLOADS WILL REMAIN IN PLACE, AND EMERGENCY SYSTEMS FOR MANY MILITARY LAUNCHES WILL BE AVAILABLE IF AND WHEN NEEDED. FINALLY, THE FINANCIAL COMMUNITY, NOW SKITTISH OF CAPITAL INVESTMENT IN SPACE WILL OBTAIN A POSITIVE SIGNAL FROM THE GOVERNMENT'S IMPLEMENTATION OF ITS STATED FULL COST RECOVERY POLICY FOR SHUTTLE THAT THE U.S. GOVERNMENT IS SERIOUS IN ITS INTENT TO OPEN UP SPACE COMMERCIALLY AS OTHER OPPORTUNITIES MATURE.

THANK YOU MR. CHAIRMAN. WE WILL BE HAPPY TO ANSWER ANY QUESTIONS YOU MAY HAVE.

Transpace
Carriers Inc

TESTIMONY OF TRANSPACE CARRIERS, INC.
BEFORE THE HOUSE SUBCOMMITTEE
FOR SPACE SCIENCE & APPLICATIONS

STATEMENT OF ANTONIO L. SAVOCA, PRESIDENT & CEO

FEBRUARY 21, 1985

Hold for release at 2:00 PM, EST, Thursday, February 21, 1985

Mr. Chairman and distinguished members of the Subcommittee: I am Antonio L. Savoca, President and Chief Executive Officer of Transpace Carriers, Incorporated. Seated with me is David W. Grimes, Chairman and Chief Technical Officer of Transpace Carriers, Inc.

We greatly appreciate the opportunity to address the subcommittee on the pricing environment in which the expendable launch vehicle industry, of which we are a part, finds itself. In particular, we want to address the impact that the NASA recommended Shuttle price for fiscal years 1989 and beyond will have on our emerging industry.

Before we do that, we wish to state that we find ourselves in a peculiar position. We are staunch proponents of the manned space shuttle. Many members of TCI management worked on the program. I was personally involved in the program from 1972 through 1982. I managed the Wasatch Division of Thiokol Corporation from the time it was awarded the Solid Rocket Motor contract in 1974 through the start of its operational phase in 1982. I strongly felt the responsibility for those Solid Rocket Motors at lift off of STS-1 as I am sure did every other participant in this program which ranks very high among man's accomplishments. I feel some of that responsibility, even today, with each succeeding lift-off. In spite of the tremendous and unsurpassed achievements of the Shuttle to date, we know that it is just the beginning for the Shuttle, as research and development experiments that will benefit the United States and all mankind, are proved out and become products for all to use. The full range of human benefits that will most assuredly accrue from the Shuttle cannot be comprehended now, just as it was impossible to fully comprehend the benefits from the discovery of electricity or the airplane in their time.

However, in order to implement the National Policy that is now opening up the gates to commercial activities in space, all participants must compete in an even handed way for commercial sector payloads. It is that issue which is the focus of today's hearing. The rational commercialization of space requires NASA to price its services for commercial and foreign users at the same full cost that commercial launch providers must charge. We do not believe that NASA's pricing proposal does so.

As you know, Transpace Carriers is operating under an agreement with NASA to transition the Delta Expendable Launch Vehicle to the private sector.

Our company was incorporated in September 1982 under the laws of Maryland, specifically for that purpose. We followed the procurement procedures set up by NASA for this activity which culminated in an agreement between NASA and ourselves, reviewed and approved by the House and Senate committees, and executed by NASA on 16 May 1984, and legislation was passed in November, 1984.

TCI MANAGEMENT

TCI has assembled an outstanding senior management team with considerable experience in the aerospace industry. The combined experience level of these five individuals is 146 years of which 98 were specifically associated with the U.S. space program. The following is a synopsis of this experience:

David W. Grimes, age 47, has been a director and Chairman of the Board since inception and Vice President - Engineering since June 1983. Prior to forming the Company in 1982, Mr. Grimes was with NASA for 19 years, serving the last five years as Project Manager, Delta Launch Vehicle Program at NASA's Goddard Space Flight Center. In this position he was the senior executive responsible for the management of the $200 million per year launching vehicle business within NASA, including all facets of production, check-out, launch services, and customer support. He is recognized as a foremost expert in the field of spacecraft launch vehicle systems. He also served as Project Manager, Shuttle Spacelab Payload; Project Manager, Atmosphere Explorers; and Engineering Manager for the Orbiting Geophysical Observatories. Prior to joining NASA, Mr. Grimes was engaged in instrumentation engineering with Air Research, Lockheed, and Hercules. Mr. Grimes received a B.S.E.E. from West Virginia University.

Antonio L. Savoca, age 61, has served as President and Chief

Executive Officer and a director since 1983. Prior to joining the Company he served for more than eight years as Senior Vice President, Morton Thiokol Corporation, and General Manager, Wasatch Division. He had profit responsibility for this $400 million, 4500 personnel, operating division of Morton Thiokol and was involved in design, development and production of highly complex solid propellant rocket motor systems for space and military applications, including the space shuttle solid rocket motors. The previous six years, Mr. Savoca was director of finance and administration, Wasatch Division. He controlled and administered finance, contracts, proposals, procurement, personnel management, information systems, internal audit, and data processing. Prior to joining Morton Thiokol, Mr. Savoca served 21 years in the Air Force in a wide variety of increasingly responsible flight and management assignments attaining the rank of Lieutenant Colonel. Mr. Savoca received a B.A. in Business Administration from the University of Oklahoma.

George F. Page, Vice President, Operations. Mr. Page has 33 years of aerospace engineering and operations experience, including 27 years of space launch operations experience. Prior to joining the company, he was Deputy Director of Kennedy Space Center. His 21 years with NASA in management positions included: Manager of Apollo Spacecraft Operations Division, Director of Expendable Launch Vehicle Operations, and Director of Shuttle Operations for the first four Shuttle missions. Prior experience included five years as Launch Operations Engineer with General Dynamics Corporation and Flight Test Engineer with the Westinghouse Electric Corporation. B.S.A.E., Pennsylvania State University.

Herbert F. Balzuweit, Vice President, Finance and Administration. Prior to joining the Company in 1984, he spent eight years with GTE Corporation in various positions of increasing responsibilities, both domestic and abroad. During the last four years at GTE, Mr. Balzuweit was Vice President, Controller of GTE Telenet Communications Corporation. Prior to joining GTE Corporation, he was associated with Arthur Andersen & Company for 8 years, responsible for audit of companies ranging from small start-up ventures to large, multi-national corporations. He left as an Audit Manager to join GTE Corporation. He is a Certified Public Accountant. B.B.A., City University of New York.

Jack W. Pinto, Vice President, Marketing. Mr. Pinto has 30 years of engineering and marketing aerospace experience and was with IBM Corporation for 23 years. Most recently he served as Director of Marketing, Owego Operations, where he was responsible for $600 million in annual sales for the 5,000-man facility. Having extensive experience working with NASA, the Air Force, and the Navy, Mr. Pinto was manager of the Field Marketing Offices for the Federal Systems Division of IBM. Prior marketing management assignments included Space Programs, NASA Programs, Ship Systems Programs, and Western Region Field Marketing. Program Involvement included Space Shuttle, Space Telescope, HH-60D Avionics and LAMPS integration. He has a B.M.E., Rensselaer Polytechnic Institute.

FULL COST RECOVERY

The Presidential Policy on commercialization of ELV's preceded our agreement by exactly one year - 16 May 1983. This policy specifically addressed the U.S. Government's desire to

> "ensure a flexible and robust U.S launch posture to maintain space transportation leadership"

and to

> "encourage the U.S. private sector development of commercial launch operations."

Further, it stated that

> "the U.S. Government fully endorses and will facilitate the commercialization of U.S. Expendable Launch Vehicles."

Under the section entitled Relationship of STS and Commercial ELV's the policy stated that

> "through FY 1988, the price for STS flights will be maintained in accordance with the currently established NASA pricing policies in order to provide market stability and assure fair competition. Beyond this period, it is the U.S. Government's intent to establish a full cost recovery policy for commercial and foreign STS flight operations."

Full cost recovery for STS pricing is certainly consistent with the goals of the overall policy to establish a commercial launch vehicle industry in the United States. A commercial industry cannot exist if it has Government competition that does not face the same economic world. The $87 Million STS price in 1982 dollars recommended by NASA to the President on 17 September 1984, for FY '89, '90, and '91 falls substantially short of full-cost-recovery as the term is known in that economic world. Indeed, given the apparent NASA definition, no rational businessman would decide to enter the industry.

If it is left to stand, the $87 Million "full-cost-recovery" price for STS recommended by NASA would cause the emerging non-shuttle dependent expendable launch vehicle industry to fail. If TCI were to fail for this reason, the millions of dollars of investor capital that has sustained us thus far would have been lost without the company ever having had a chance to succeed in the marketplace.

The extent of the deviations from full cost can be demonstrated easily. Please examine the chart we have prepared. A more detailed copy of the chart is attached for the record. All of the amounts on the chart are in 1982 dollars and are per unit numbers with the unit being one STS payload bay. We used the data in the NASA recommendation to the President as a baseline and adjusted it for known omissions that could be readily quantified. Column 1 is hardware cost and Column 2 is the per unit operations budget. Column 3 is NASA's recommended flight rates per year. Based upon NASA's past accomplishments and facilities limitations Column 4 is the rate we believe NASA may achieve on the high side. Column 5 is the sum of Columns

1 and 2 and, in the three years bounded by the horizontal lines, is NASA's recommended payload bay calculation for FY '89, '90, and '91 of $83.9, $83.6, and $82.5 Million which the agency adjusted up to an average of $87 Million. Column 6 applies our correction for the lower flight rate which we calculated by taking Column 1 and adding to that the sum of Column 2 times Column 3, divided by Column 4. Column 7 is orbiter amortization arrived at by assuming a low orbiter cost of $1.5 Billion, divided by the 100 flight design life per orbiter. An interesting sidelight of this is that if we amortize only 3 of the 4 orbiters in 1995, when it is estimated by NASA that the STS will be transitioned to the privte sector, there will remain a $2.25 Billion unamortized balance for orbiters alone that would have to be recovered in the commercialization process. Column 8 represents the cost of money computed at 10% per year for 10 years on the cost of 3 orbiters only. Column 9 is orbiter insurance computed at a very low figure of 2% of the replacement value of one orbiter. Column 10 is a correction of Column 1 hardware, labor only, for a more realistic labor learning curve of 93% rather than the 80 - 88% curves it appears NASA used. Column 11 is the sum of Columns 6 thru 10 which yields an average price of $188 million per payload bay. The expendable launch vehicle industry would be viable at $150 million payload bay price in 1982 dollars. The $188 million estimate still does not include many items because we had no way of determining the appropriate dollar amount to be added even though these

additions would represent substantial costs. It does not include:

- Dollars for sustaining R&D or system upgrades,
- Offset for taxes which commercial ELV's must pay,
- Offset for return on investment which commercial ELV's must earn,
- Facility or equipment cost included to make the higher flight rate,
- Cost for NASA's commercial marketing effort.

In addition to the above, experience indicates that the operations base is over-optimistically calculated. The operations base (Col. 2 times Col. 3) in 1984 totals $1.1B for 8 flights. It is doubtful that the operations base can decrease in 1989 to approximately $.9B (Col. 2 times Col. 3) while tripling the flight rate to 24 launches per year.

If the United States Government is to be in competition with the commercial expendable launch vehicle industry, then the United States must charge commercial users all costs that commercial companies must charge. If this is not done, the United States will drive out of business the industry it has encouraged to develop. Certainly, a question to consider is whether or not it is in keeping with the economic objectives of a free economy to have Government compete with private industry at all?

ARIANE AND THE 301 FILING

Another factor in the expendable launch vehicle economic world is the foreign Government competition from the ESA nations Ariane System, led by the French. This system has maintained a two tier pricing structure for the same service wherein they charge ESA nations a much higher price than launches sold in the United States and outside the ESA nations. This has been freely admitted by Mr. F. d'Allest, Chairman of Arianespace S.A. and Director General of CNES at the Satellite Summit Conference held at the Watergate Hotel, here in Washington, D.C. on 7 December 1982 when he said,

> "(We) asked our European member states in ESA to support Ariane sales during the first three years through a price differential of 25 percent. That means that European payloads are paying during the first three years of the STS pricing policy some 25 percent more than the export sales to help us to balance a bit this subsidy."

The fact that he said, to help balance a "bit" this subsidy would lead one to believe that the subsidy was much greater than 25 percent.

On February 25, 1982, in a statement before the Senate Subcommittee on Science, Technology and Space, he made much the same statement, putting the blame for the subsidy on NASA. At that time he testified:

> "When establishing ARIANESPACE we succeeded in convincing ESA and its member States that the STS pricing policy during the first three years of its operations involved a huge subsidy, thus creating an unfair competition. In response it was agreed that for the European payloads launched before mid-1986 the standard price negotiated with ESA and

> specified in the ESA/ARIANESPACE Convention would include a 25% extra charge to support the company. We consider, and I hope you will consider that these practices are not very sound, as they charge the research and development programs on both sides of the Atlantic, instead of charging the users who reportedly look to gain great financial profit from their commercial applications. We permit ourselves to underline the fact that the orbiters' production costs should also be fully charged to the customers, with the related cost of money. As long as the STS production and operations costs do not reflect realistically the STS pricing policy we shall claim some support through the European payloads launch prices, to ESA and its member States."

We have found that since Transpace Carriers entered the marketplace, Ariane has been subsidizing prices to an even greater extent. Before TCI, Ariane charged a subsidized price of about $25 million per Delta class payload outside the ESA nations and about $32 million to the ESA nations. We have now seen prices in the $19-20 million range outside the ESA nations.

On May 25, 1984, we submitted a petition to the United States Trade Representative seeking Presidential action under Section 301 of the Trade Act of 1974 to bring to an end the ESA nations subsidy of the Ariane system. Our petition was accepted by the Trade Representative on July 9, 1984, and the process is underway. To date, there have been two consultations with the ESA nations who have as a member of their 301 delegation France's Mr. d'Allest. The third consultation is currently in session, and by law, the entire process must be completed on or before July 11, 1985. During these consultations, it is our understanding the ESA nations have reiterated their position that they would like to end their subsidy if NASA would go to a commercial full cost recovery price for the STS proceedings. It is possible that resolution of the issue could come quickly at a price level which would be conducive to U.S. commercial expendable launch vehicle viability if both the Ariane and STS prices could be addressed in the 301 forum.

Such a result would be beneficial to the United States. Atlas Centaur and Delta Expendable Launch Vehicles would survive in the commercial arena, maintaining for the United States two systems of unparalleled reliability which complement each other. In addition to the commercial market anticipated, these systems could be used by the U.S. to fly government payloads during times of emergency and to alleviate any potential STS schedule problems that might result from increased commercially oriented research and development payloads of value to the United States and mankind. It would signal a skeptical financial world that the United States is serious about providing commercial opportunities in space whenever possible. It would maintain, and set the ground work for, expansions and improvements of an established ELV technological base including people, facilities, and hardware, and it would maintain U.S. leadership in space across the broadest front.

We have had many written expressions of support for our 301 petition from members of Congress as well as industry and industry associations.

TCI STATUS

We have negotiated major hardware supplier contracts with McDonnell Douglas, for the core vehicle and systems integration, and with Morton Thiokol, for the Castor solid rocket motor strap-on boosters. We are in the final stages of completing our negotiation with Rockwell Corporation for the 1st stage liquid engines. We are working with First Boston Corporation who has agreed to raise the substantial capital required to start and sustain the production activity until cash flow from sales can sustain it. Success in the financial market is heavily dependent on unsubsidized government competition.

In addition to First Boston Corporation's activities, Bank of America has agreed to a $15,000,000 line of credit for TCI against contracts. Bank of America is willing to provide a $35,000,000 customer financing package wherein a credit worthy customer can finance his launch on a seven year program with payments deferred to the last five years.

TCI strongly believes that full commercial cost recovery is the only economically sound policy for a free market nation to follow. We believe the arguments advanced for continuing less than full cost recovery STS prices are not sound.

ALLEGATIONS AND COUNTER ARGUMENTS

Some allege that Delta is old technology. In fact, the U.S. ELVs have been consistently upgraded and enhanced by NASA in order to assure the use of state of the art technology in launch systems and ground systems. This technology and program knowhow have been the reason for Delta's continued, unparalleled success. An outstanding example of Delta contemporary technology is the skin structure which achieves very high structural efficiency resulting in much lower weight than the Ariane ELV. Also, the guidance system is new, highly accurate, and unsurpassed in efficiency and reliability for the launch missions it serves. The engines also are the beneficiaries of not only the man-rated Saturn program and the TITAN program, but also have achieved extensive flights on the Delta and Atlas programs.

It has been alleged that the market is too small to support commercial ELVs and the space shuttle. TCI strongly disagrees and believes that the opposite is true. Communications satellite usage worldwide is increasing, providing business opportunities for U.S. ELVs while the Space Shuttle will be the only manned reusable launch system to support the Space Station and most of the space industries which the Center for Space Policy quotes as exceeding $60 Billion in revenue by the year 2000. TCI estimates the commercial and foreign satellite market for the Delta payload class alone to be on average about 20 per year, not counting the European payloads committed to Ariane.

These numbers are supported by various studies including the Battelle Memorial Outside User's Payload Model prepared annually for NASA. NASA Customer Services, in contrast, has recently stated publicly that the market for domestic and foreign communications will flatten out by the end of this decade to 7 or 8 per year. Yet NASA's planning for 1990 and 1991 indicates that commercial and foreign satellites will occupy the equivalent of 4.2 STS cargo bays. Based on NASA's equivalency factor and planned market share of 75%, this represents a total commercial and foreign market of 28 equivalent Delta class payloads. In a paper presented by Hughes Aircraft to the World Telecommunications Forum in December 1983, it was indicated that there will be 33 foreign national communications satellites alone by October 1987. It was further stated that

> "The number of national systems is accelerating. They are doing so because they are an economical way to build long distance networks rapidly, both in developing nations and inaccessible regions of advanced nations."

In addition, new international and inter-regional communications will yield greater opportunity for the space launch vehicle industry. Meteorology and remote earth sensing will continue to expand as foreign countries become more space independent.

It has also been alleged that full cost will result in Ariane capturing the entire marketplace. This assumes that U.S. ELVs will not be competitive on a level playing field which the 301 proceeding is intended to obtain. In addition, Ariane may face operational limitations. Currently the Ariane 4 can only be launched from the second launch pad at Kourou, French Guiana.

With existing facilities, Arianespace claims that 12 per year can be achieved. This is highly doubtful since Delta, with a much smaller vehicle, two launch pads, and 25 years of launch experience reached a maximum of ten per year. Probably, a more important factor favoring U.S. ELVs is that their single payload, dedicated mission service provides high confidence of full insurability.

In short, Ariane is incapable of launching the entire commercial and foreign market. The presence of U.S. commercial ELVs in concert with the space shuttle will assure that Ariane will fall far short in achieving the market ascribed to them by those who advance this argument. American industry should not be sold short on its ability to compete effectively with its foreign counterparts if trade is conducted under the rules of the Trade Act of 1974.

Another alleged result of shuttle full cost recovery is that the high cost of launch will drive users from satellites to fiber optics systems. A recent Intelsat analysis indicates that in this wave of fiber optics popularity, satellites in addition to providing multipoint capability also provide on a per circuit basis a 30 to 70% cost savings compared to fiber optics. If the launch costs, for example, were to be doubled, and amortized over a ten year period, the resultant increase in transponder cost would be less than 10 percent, hardly enough to drive users from communication satellites.

Another argument often heard against full cost recovery is that it will cause potential space technology investors and developers to rethink these investments. TCI believes that R&D in space manufacturing and other commercially oriented experimentation should have low cost access to space. Mature industries such as space communications should not, and do not, require government subsidy to be profitable. Likewise, when space manufactured products become mature and commercially viable, they too should not require or expect subsidization in any form. The Presidential policy directs full cost recovery for only commercial and foreign STS flight operations and allows for subsidized prices for research and development activities. This was emphasized by the Science Advisor to the President in his October 15, 1984, letter in response to Senator Gorton's letter of August 31, 1984.

One last argument against full cost recovery often advanced is that it would make the upper stages deployed from the shuttle non-competitive. Upper stages are expendable vehicles used to deliver satellites from the shuttle's 160 mile orbit to a geostationary orbit 22,300 miles above the earth's equator. With ground launched ELVs, the upper stage is part of the launch vehicle.

There are several upper stages which are either operational or at some stage of development, most of which are cost effective for specific classes of spacecraft. No upper stage, however, should depend on a subsidy of its low earth orbit transportation in order to be economically viable. If such subsidy is allowed, it will place the non-shuttle dependent ELV industry at an unfair competitive position vis-a-vis the shuttle/ expendable upper stage combination. When Ariane and Shuttle price subsidies are removed, charging commercial full cost for Shuttle services would not affect expendable upper stage providers since they would compete on merits and costs of services they provide using Shuttle priced on a level playing field.

SUMMARY

In summary, Transpace Carriers, Inc. would like to compete in a free market economy consistent with the tradition of this nation. We entered this business relying on the STS going to full cost recovery in FY '89. We believed that the ESA nations were weary of their subsidy and would follow the STS price up. If they did not, we were prepared to file a 301 petition. We filed the petition earlier than we had originally anticipated because they drastically reduced their price coincident with our signed agreement with NASA to transition Delta to the private sector. The structure of the space launch industry providing transportation to the 22,300 mile transfer orbit now contains: (1) companies which are totally commercial, Transpace

Carriers and General Dynamics, who must recover their entire cost plus a return on investment for the entire trip: (2) a quasi-private company, Arianespace, which is 60% owned by France and is subsidized by the ESA member nations; and, (3) private upper stage companies, McDonnell Douglas, Orbital Sciences, and others, which utilize the government subsidized shuttle for what is essentially the first and second stages of their operation. Government subsidy in any part of this structure distorts the operation of a free economy resulting in a misallocation of resources. These subsidies will ensure the failure of the truly private companies who are not dependent upon government subsidy. Failure to permit an economically sound environment for the commercialization of U.S. ELVs would mean the effective elimination of the two most reliable launch vehicles in the world and the forfeiture of this growing market and technology to foreign interests which are pursuing development and production of ELVs.

On the other hand, successful commercialization of U.S. ELVs can provide the U.S. with a continued leadership position in this segment of space launch services, technical capability will be preserved for the United States and new ELV innovation will occur stimulated by market demand. Balance of payments will be enhanced, U.S. launch back up to the STS for ELV class payloads will remain in place, and emergency systems for many military launches will be available if and when needed. Finally, the financial community, now skittish of capital investment in space will obtain a positive signal from the government's implementation of its stated full cost recovery policy for shuttle that the U.S. government is serious in its intent to open up space commercially as other opportunities mature.

Thank you Mr. Chairman. We will be happy to answer any questions you may have.

PROJECTED SHUTTLE PRICE FOR COMMERCIAL FOREIGN AND DOMESTIC SATELLITE LAUNCHES
ALL AMOUNTS IN $1982M

YEAR	PER UNIT $82 HOME BUDGET	PER UNIT $82 OPS BUDGET	FLIGHTS PLANNED	FLIGHTS ESTIMATE	NASA COST/FLT	REIVSED COST/FLT	ORBITER AMORTIZ	COST OF MONEY	ORBITER INSURAN	LEARNING FACTOR ADJUST	TOTAL REVISED PRICE
	COL 1	COL 2	COL 3	COL 4	COL 5	COL 6	COL 7	COL 8	COL 9	COL 10	COL 11
1984	100.9	137.3	8	4	238.2	375.5	15.0	89.5	30.0	40.4	550.4
1985	83.6	78.4	11	7	162.0	206.8	15.0	51.1	30.0	33.4	336.4
1986	58.8	60.3	16	10	119.1	155.3	15.0	35.8	30.0	23.5	259.6
1987	52.1	42.4	21	13	94.5	120.6	15.0	27.5	30.0	20.8	214.0
1988	47.7	40.2	23	14	87.9	113.7	15.0	25.6	30.0	19.1	203.4
1989	44.8	39.1	24	15	83.9	107.4	15.0	23.9	30.0	17.9	194.1
1990	42.6	41.0	24	16	83.6	104.1	15.0	22.4	30.0	17.0	188.5
1991	41.2	41.3	24	17	82.5	99.5	15.0	21.1	30.0	16.5	182.0
1992	40.9	41.1	24	18	82.0	95.7	15.0	19.9	30.0	16.4	176.9
1993	40.9	39.3	24	18	80.2	93.3	15.0	19.9	30.0	16.4	174.5
1994	37.8	39.6	24	18	77.4	90.6	15.0	.0	30.0	15.1	150.7
TOTAL			223	150							

COL 1 & COL 2 - FROM NASA 17 SEP 84 SUBMITTAL UNCHANGED. BOTH COLUMNS 1 AND 2 ARE HIGHLY OPTIMISTIC, HOWEVER SUFFICIENT DETAIL IS NOT AVAILABLE FROM NASA TO VERIFY INCREASES

COL 3 - FROM NASA 17 SEP 84 SUBMITTAL UNCHANGED

COL 4 - MORE REALISTIC SHUTTLE FILGHT RATE

COL 5 - COL 1 + COL 2

COL 6 - COL 1 + (COL 2 TIMES COL 3 DIVIDED BY COL 4)

COL 7 - $1500M DIVIDED BY 100 FLIGHTS (NASA EST. ORBITER DESIGN LIFE) AMORTIZED ONLY 3 OF 4 ORBITERS (ONE ORBITER EXCLUDED AS R&D) LEAVING UNAMORTIZED BALANCE OF $2250M IN 1995, THE YEAR NASA ANTICIPATES SHUTTLE TO GO TO TO PRIVATE SECTOR OPERATION. HIGHLY UNLIKELY PRIVATE SECTOR WOULD PAY SUCH A LARGE AMOUNT.

COL 8 - COST OF 3 ORBITERS = $4500M. CONSTRUCTION INTEREST IS $465M PLUS $3113M @ 10% FOR 10 YEARS = $3578M DIVIDED BY 10 YEARS = $358M PER YEAR DIVIDED BY ANNUAL FLIGHT RATE

COL 9 - ORBITER INSURANCE UNDETERMINED BUT SHOWN AT A VERY NOMINAL RATE OF 2% PER FLIGHT

COL 10 - 93% LEARNING CURVE VS 80-88% PROJECTED BY NASA OVERALL. 93% USED ON HARDWARE LABOR ONLY

COL 11 - SUM OF COLUMN 6 THRU COLUMN 10

NOTES

(A) NO DOLLARS INCLUDED FOR SUSTAINING R&D, SYSTEM UPGRADES OR ANOMALY INVESTIGATION

(B) NO OFFSET FOR TAXES WHICH COMMERCIAL ELV'S MUST PAY

(C) NO OFFSET FOR RETURN ON INVESTMENT WHICH COMMERCIAL ELV'S MUST EARN

(D) NO FACILITY OR EQUIPMENT COST INCLUDED TO MAKE HIGHER FLIGHT RATE

(E) NO COST FOR NEW NASA COMMERCIAL MARKETING EFFORT INCLUDED

(F) THE OPERATIONS BASE (COL 2) IN 1984 TOTALS $1.1B FOR 8 FLIGHTS. IT IS DOUBTFUL THAT THE OPERATIONS BASE CAN DECREASE TO APPROXIMATELY $.9B WHILE INCREASING THE FLIGHT RATE TO 24 PER YEAR.

NOT RECOMMENDED FOR COMMERCIAL RESEARCH AND DEVELOPMENT PAYLOADS TO BE FLOWN ON SHUTTLE

Mr. NELSON. Thank you, Mr. Savoca. I would renew my invitation to those standing by the door to come over and make use of the empty seats. There are a couple out there in the audience too. So, unless you enjoy standing, you're welcome.

Dr. Scherer.

STATEMENT OF DR. LEE R. SCHERER, DIRECTOR, COMMERCIAL SPACE, GENERAL DYNAMICS CORP., CONVAIR DIVISION

Dr. SCHERER. Thank you, Mr. Chairman. To you and the members of the subcommittee, it's an honor to appear before this distinguished committee as a representative of the General Dynamics Corp. to discuss the viability and future of expendable launch vehicles as an important national asset.

I would like to commend Chairman Nelson and the other members of the subcommittee for convening this hearing at this time. I believe that the subject matter with which we will deal today is not only of great importance to people associated with the specific programs, but to all Americans who share our pride in this Nation's pre-eminence in space.

My job at General Dynamics is to run the commercial space program office, and by way of background for some of the committee members, who I don't know, I had 5 years as director of the Kennedy Space Center and several years as a consultant on space commercialization.

Mr. Chairman, with your permission, I'd like to submit the full statement for the record and read from an abbreviated version.

Mr. NELSON. Without objection.

Dr. SCHERER. General Dynamics has been involved in our space program since its inception. Just prior to the launch of Sputnik in 1957, we flew the first Atlas rocket. Now, we've flown some 480, 197 of which have been for space missions, including such programs as Mercury, Ranger, Mariner, NOAA, Navstar and many others. In 1962 we flew the first high energy upper Centaur. Centaur has now flown on 62 Atlas Centaurs and seven Titan Centaur. Atlas/Centaur alone had launched about one-third of the communication satellites launched in the United States. Nearly all of our planetary and interplanetary missions, as well as many scientific missions, have been launched from either the Atlas and/or Centaur. These include Surveyor, Pioneer, Viking, Voyager, and others.

General Dynamics is particularly proud of its association with the Space Shuttle Program. We designed and built the midfuselage for the orbiters. Currently we are modifying the Centaur for use as an upper stage to launch NASA's planetary missions, Galileo and Ulysses, from the shuttle bay. The Centaur-in-Shuttle Program will service not only NASA missions, but also priority national security missions requiring Centaur's high performance.

As a corollary to the development of the space shuttle, the U.S. Government made a conscious decision to phase down and eventually terminate the expendable launch vehicle programs with the expectation that the shuttle would be able to handle all available traffic. It was believed there would be no further need for ELV's by the early 1980's.

Ironic about our decision to terminate American ELV's is that in doing so we created an international competition. The European Space Agency, desiring independence from U.S. launch vehicles and skeptical about our shuttle rationale, proceeded with the development of their own ELV, Ariane. Time has proven that the Europeans' analysis, which lead to the development of the Ariane, was sound. Indeed there was still a need for ELV launches. Ariane has emerged today as a formidable competitor with a well-sized booster system, substantial financial backing from European banks and government, and aggressive marketing.

We were pleased by the issuance, last year, of an administration policy of allowing the commercialization of U.S. ELV's, as well as the designation of the Department of Transportation to encourage and facilitate commercial ELV activities by the private sector.

The affirmative action taken by this committee last year in its passage of legislation to provide for commercialization of ELV's has greatly encouraged our efforts.

The U.S. ELV industry today is well positioned to move into the commercial market. If our industry is viable we will maintain the know-how for producing and launching ELV's, a national resource cultivated and constantly improved over many years. Once stopped, tooling dismantled and the skills disbanded, it is highly unlikely that production could ever restart in such a way that it would be competitive with the ongoing and developing foreign launch vehicle competition not only Europe, but also Japan, China, and Russia. Japan is building the H-1 and H-2 engines that will be—enable them to compete. China has just announced that they are going to offer their long March-3 vehicle as a commercial—for commercial users, and Russia is trying hard to commercialize their Proton vehicle.

When commercial satellites are considered in conjunction with the planned DOD, NASA and other U.S. Government missions, we believe the launch demand exceeds the capability of the shuttle. NASA has manifested payloads to fill the projected high-launch the Orbiter fleet is capable of obtaining. This rate projects a sharply upward learning curve, which exceeds the NASA experience to date. If the high-launch rate is not obtained there will be an overflow of commercial vehicles to the ELV's and the United States should compete for such launches.

The space shuttle is a magnificent technological development best suited for the types of missions which ELV's are unable to provide. Because of the shuttle we are able to design payloads and missions which we never before have flown. We're able to produce new materials in space, repair, retrieve and rescue, as has been so beautifully demonstrated already and to give our national security community a new flexibility.

The existence of American ELV's, which will attempt to compete against the Ariane and other foreign ELV's will allow the shuttle to concentrate more on unique missions that push the edge of science and technology. This is the strength of NASA that has produced such magnificent achievements directly and spinoffs, whose values are legendary.

There are certain concerns that must be carefully considered by those making the decisions regarding shuttle pricing policy, which in turn will determine the viability of U.S. ELV's. If, in the unfortunate event that there was ever a technical reason to temporarily ground our fleet of Orbiters, would it not be desirable for the United States to have ELV's available for that contingency?

Second point, since cost per flight is so dependent on launch rate, if the stated administration policy of full cost recovery is followed, what is the number of shuttle flights per year that reasonably can be expected?

Third, considing the national priority of reducing current budget deficits, to what extent should the United States support the difference between the cost of the space shuttle and the launch price. And having considered that, to what extent is it reasonable to support one launch—national launch system over another, in terms of that Government assistance.

The fifth point, if the shuttle prices increase, will Ariane's price increase similarly to cover their cost or would Ariane keep their price low to capture a greater market share. If it's the latter Ariane is already indicating a launch rate per year equivalent to the best the U.S. has ever achieved with comparable ELV's. Can they improve beyond this to launch this greater number of payloads?

The next point, Mr. Chairman, I think is particularly important. How fast will the programs develop if they require extensive use of the shuttle for which there is no alternative? Among these are: One, precurser test flights for the space station, in which systems and subsystems are tested in Orbit; two, the space defense initiative requirements and yesterday's news states that these could start as early as 1987; three, possible joint rescue missions with the U.S.S.R. Those of us who were involved with Apollo/Soyuz know how bright and disruptive the international spotlight can be on international missions of this type; and four, materials processing, which holds such great promise, as Mr. Walker stated.

Mr. Chairman, I believe these are the needs that are going to expand downstream to justify the fifth Orbiter or maybe better, the first Orbiter 2.

If several of these areas essentially fully occupy the shuttle manifest for the next several years, and there are no U.S. ELV's, there will be an Ariane monopoly. And won't this hasten to the commercial marketplace the other developing launch vehicles from China, Japan, and Russia?

My final point is recently NASA spokesmen have indicated that everything possible would be done to hold the schedule for commercial space launches, including delaying Government payloads, if necessary. Given the subject being considered by this committee today, is that reversal of NASA's original priority sensible? Would it not be better for NASA to hold the higher priority for Government payload?

The answers to these questions require conjecture on the part of many of us. But, basically we believe it clear that it is not in the best interest of our country to see the magnificent potential of the space shuttle eroded by a price war with a foreign competitor in order to attract the commercial customer, whose motivation is to maximize their profit.

Our recommendation is that we heed the words of the President last year as he encouraged ELV commercialization. And I quote, "We're going to bring into play America's greatest asset, the vitality of our free enterprise system."

We do not wish to see one American space launch system receive a favored status over another. Our request is merely that we be able to compete on an equitable basis and with a national priority in mind that will seek to utilize the space shuttle for its uniqueness and ELV's for commercial transportation into space as a shuttle backup. Together they provide a more total reliable and comprehensive space launch system for this country.

Mr. Chairman, I appreciate the opportunity of expressing these views and I'd be pleased to respond to questions.

[The prepared statement of Dr. Scherer follows:]

STATEMENT OF
LEE R. SCHERER
DIRECTOR, COMMERCIAL SPACE
GENERAL DYNAMICS CORPORATION
CONVAIR DIVISION

before the

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

February 21, 1985

Mr. Chairman and Members of the Subcommittee:

It is a distinct honor to appear before this distinguished Committee as a representative of the General Dynamics Corporation to discuss the viability and future of an important national asset - Expendable Launch Vehicles (ELV's).

I would like to commend Chairman Nelson and the other members of the Subcommittee for convening this hearing at this time. It is my belief that the subject matter with which we will deal today is not only of great importance to people associated with the specific space program, but indeed to all Americans who share our pride in this nation's pre-eminence in space.

General Dynamics has been involved in the United States space program since its inception. A few months prior to the Soviet Union's launch of Sputnik in 1957, General Dynamics flew its first Atlas rocket. Our Atlas launches include such notable U.S. space programs as MERCURY, RANGER, MARINER, SCORE, OGO, TIROS, NOAA, NAVSTAR, and others. To date 480 Atlases have flown, 197 of which were for specific space launches.

Subsequent to General Dynamics' development of the Atlas, we began development of this nation's first High Energy Upper Stage, Centaur. To date Centaur has flown on 62 Atlas/Centaur vehicles and 7 Titan/Centaur vehicles. Atlas/Centaur alone has launched more than one-third of the 82 commercial communications satellites launched from the United States. Nearly all planetary and interplanetary missions of the United States as well as many scientific missions have been launched on either or both the Atlas and Centaur. These launches include such successful missions as SURVEYOR, PIONEER, OAO, MARINER, HEAO, HELIOS, VIKING, AND VOYAGER.

The General Dynamics Corporation is particularly proud of its association with the Space Shuttle program. We designed and built the mid fuselage for the Space Shuttle Orbiters. Currently we are modifying the Centaur for use as a High Energy Upper Stage to launch NASA's planetary missions, GALILEO and ULYSSES, from the Space Shuttle bay. The Centaur-in-Shuttle program will serve not only NASA missions but also priority national security missions requiring Centaur's high energy performance.

The Space Shuttle was conceived as a reusable vehicle that would transport crews and payloads to low earth orbit. In addition to the Space Shuttle's role as an important national asset, it provides a unique capability by virtue of its very large payload capacity, on-orbit versatility, and recovery capability. The presence of man increases the Space Shuttle's flexibility for mission implementation. Capabilities for extra-vehicular activity, problem solving, and on-orbit repair capability are significantly increased and have already been beautifully demonstrated. Only a vehicle such as the Space Shuttle could make possible the prospect of convenient Space Station logistics support, retrieval and return to earth of low altitude spacecraft, commercially produced products such as pharmaceuticals and crystals, or valuable test samples which have been left in orbit.

As a corollary to the planned development of the Space Shuttle, the U.S. Government made a conscious decision to phase down and eventually terminate the Expendable Launch Vehicle programs with the expectation that the Space Shuttle would be able to handle all available traffic at a cost and schedule to satisfy all potential customers. It was believed there would be no further need for ELV's by the early 1980's.

What is ironic about our decision to purposely terminate American ELV's is that in so doing we created an international space launch competition. The European Space Agency, desiring independence from U.S. launch vehicles and skeptical about the U.S. Space Shuttle rationale, proceeded with the development of their own ELV, the Ariane. Time has proven that the Europeans' analysis which led to the development of the Ariane was sound--indeed there was still a need for ELV launches. The Ariane has emerged today as a formidable competitor with an advantageously-sized booster system, progressive financing strategies, substantial financial backing from European banks and governments, and aggressive marketing.

We were pleased by the issuance last year of an Administration policy aimed at allowing the commercialization of U.S. ELV's and associated services as well as the Administration's designation of the Department of Transportation to encourage and facilitate commercial ELV activities by the private sector.

The affirmative action taken by this Committee last year in its passage of legislation to provide for commercialization of ELV's and associated services has greatly assisted our efforts to date.

The U.S. ELV industry is well positioned to move into the commercial market at this time. If our industry is viable we will maintain the knowhow for producing and launching ELV's, a national resource cultivated and constantly improved over many years. Once stopped, the tooling dismantled, and the skills disbanded, it is highly unlikely that production would ever restart in such a way that it would be competitive with the ongoing and developing foreign launch vehicle competition from France, Japan, China, and Russia.

When commercial communication satellite launch requirements are considered in conjunction with the planned DoD, NASA, and other U.S. Government missions, we believe that the demand exceeds the capability of the Space Shuttle. NASA has manifested payloads to fill the projected high launch rates the Orbiter fleet is capable of attaining. This rate projects a sharply upward learning curve which exceeds the NASA experience to date. If the high launch rate is not attained there will be an overflow of commercial payloads to ELV's. The United States should be able to compete for such launches.

The Space Shuttle is a magnificent technological development which, I believe, is best employed for new types of missions which ELV's are unable to provide. Because of the Space Shuttle we are able to design varieties of payloads which we never before have flown. Because of the Space Shuttle we are able to produce new materials in space, provide repair, retrieval, and rescue operations, and give our national security community a new flexibility. The existence of American ELV's which will compete against the European Ariane and other developing foreign ELV's will allow the Space Shuttle to concentrate on unique missions that push the edge of science and technology. This is the strength of NASA that has produced such magnificent achievements directly and spinoffs whose values are legendary. It is my belief that the goal of the American space community should be to provide more types of service in more different ways so that we are not overly dependent on a single solution.

There are certain concerns that must be carefully considered by those making the decisions regarding Shuttle pricing policy.

- If in the unfortunate event that there was ever a technical reason to temporarily ground our fleet of Space Shuttle Orbiters, would it not be desirable for the United States to still have ELV's available for that contingency?
- Since cost per flight is so dependent on launch rate, if the stated Administration policy of full cost recovery is to be followed, one must make a judgment on the number of flights per year that can be expected. Will NASA be able to improve on the forecast schedule and achieve the maximum rate planned?

- Considering the national priority of reducing current budget deficits, to what extent should the United States support the difference between the cost of the Space Shuttle and the launch price? Having considered that, to what extent is it reasonable to support one national launch system over another in terms of that government assistance?

- If the Shuttle price is increased, will Ariane's price increase similarly to cover their costs, or will Ariane keep their price low to capture a greater market share? If the latter, Ariane is already indicating a launch rate per year equivalent to the best the U.S. has ever reached with comparable ELV's. Can they improve beyond this to launch this greater number of payloads?

- How fast will the programs develop that require extensive use of the Shuttle for which there is no alternative? Among these are: precurser test flights for the Space Station in which systems and subsystems are tested in orbit; the Space Defense Initiative requirements; possible joint rescue missions with the USSR; materials processing which holds such great promise. If several of these areas essentially fully occupy the Shuttle manifest after the next few years and there are no U.S. ELV's, will this hasten to the commercial marketplace other launch vehicles from Japan, China, and Russia to challenge the resultant Ariane monopoly?

- Recently, a NASA spokesman indicated that everything possible would be done to hold the schedule for commercial space launches, including delaying Government payloads, if necessary. Given the subject being considered by this committee today, is that reversal of NASA's original priority sensible? Would it not make more sense for NASA to hold a higher priority for Government payloads including unique missions for which the Shuttle is configured?

The answers to these questions require much conjecture on the part of any of us. However, I do not think it's in the best interests of our country to see the magnificent potential of the Space Shuttle eroded by a price war with a foreign competitor in order to attract the commercial customer whose motivation is to maximize profit.

With the unknowns that lie ahead over the next several years, my recommendation is that we heed the words of the President last year as he encouraged ELV commercialization; "So, we're going to bring into play America's greatest asset; the vitality of our free enterprise system."

We do not wish to see one American space launch system receive a "favored status" over another. Our request is merely that we be able to compete on an equitable basis and with a national priority in mind that will seek to utilize the Space Shuttle for its uniqueness and ELV's for commercial transportation into space as a Shuttle back-up. Together they provide a more total reliable and comprehensive space launch system for this country.

Mr. Chairman, I appreciate the opportunity that you have provided to me to present these views. I will be pleased to respond to any questions you might have. Thank you.

Mr. **Nelson**. Thank you, Dr. Scherer.

First of all I'd like to ask both of you, what is the total amount of money that each of your firms has invested in your ELV ventures, and I'm going to have to hold a tight rein on your answers, because we're running out of time. Go ahead, Mr. Savoca.

Mr. **Savoca**. OK, in 5 seconds, we have $9 million invested. We've got $25 million committed. We've got an additional $60 million that is being—that is being raised by First Boston.

Mr. **Nelson**. $9 million that has been utilized to date?

Mr. **Savoca**. $9 million that we are on the road to utilizing. We have not spent $9 million to date.

Mr. **Nelson**. All right, Dr. Scherer.

Dr. **Scherer**. Mr. Chairman, I can't give you an answer today. And I'd like to submit one for the record. We have a commercial space office, we're using our advanced program offices, we're doing cost reduction studies and a number of design studies and I'll just have to get them summarized.

Mr. **Nelson**. All right, for both of you, again. What you know about the economics of the ELV, at what price level would a full space shuttle launch have to be set for your ELV to be competitive with the shuttle? Mr. Savoca.

Mr. **Savoca**. We think our minimum price level is $150 million in 1982 dollars.

Mr. **Nelson**. Dr. Scherer?

Dr. **Scherer**. Sir, we don't have a policy on what that should be. As you know, General Dynamics is on both sides of this equation, but I can say this, I have been involved with intensive marketing exercises over this past year that I've been with General Dynamics, and there is no opportunity for straight sale at the price that we have quoted, so we have been attempting to organize around innovative business arrangements and those who are interested in talking with us are the startup companies, who need the financial strength of General Dynamics, which would mean, of course, they're willing to pay a premium price for that.

So, I don't have a firm number to give at this time. If you'd like, I would submit that for the record.

Mr. **Nelson**. OK, for both of you. What level of an annual launch rate is required for your launch vehicles to achieve a cost-efficient production level? Mr. Savoca?

Mr. **Savoca**. Our's is set at between five and six with $150 million 1982 dollars shuttle bay price.

Mr. **Nelson**. Dr. Scherer.

Dr. **Scherer**. Our general plans, sir, have been for launching four per year, which is an optimum launch rate for the launch crews that we have. We can go higher, if we had more customers, by increasing our launch crews.

Mr. **Nelson**. Mr. Savoca, if technical problems, serious technical problems, were to arise with the Delta in the future, would you have the necessary people and funds to resolve it?

Mr. **Savoca**. Yes, we believe that we would.

Mr. **Nelson**. Some people are saying now that the size of the satellites are growing to such an extent that in a few years that the Delta would be no longer able to lift them, is that true?

Mr. **Savoca**. Some people are saying that, yes.

Mr. NELSON. Is the conclusion of that statement true, in your opinion?

Mr. SAVOCA. No, we don't think the conclusion of that statement is entirely true. There are technologies that work both ways. There are technologies that are working to reduce the size of satellites, and of course the economic background in which launch vehicles operate will play an important part in that. Now, for example, if launches are free, then resources probably will not be invested to try and reduce the capability or provide more capability per satellite. So, the entire—the entire subject is wrapped up in one economy that has to be considered.

Mr. NELSON. Well, how much of an increase in the lift capability of the Delta is possible?

Mr. SAVOCA. I defer to our chief technical officer and chairman and he'll be able to answer that.

Mr. GRIMES. Mr. Chairman, we feel that Delta can be increased, with its current capabilities, up to about 5 thousand pounds in the 1990 timeframe.

Mr. NELSON. And how much would that R&D effort cost?

Mr. GRIMES. That would be under $100 million.

Mr. NELSON. And where would you propose to pay for that $100 million R&D?

Mr. GRIMES. That would come out of company revenues and would be paid out of about an amortization over the first 10 flights, making use of that hardware.

Mr. NELSON. So, the user fees for those first 10 flights would be increased to cover that amortization over those 10 flights?

Mr. GRIMES. Yes, that's right. And there's a concomitant increase that's less than the per unit cost and the pound—dollars per pound to orbit base for that kind of development activity.

Mr. NELSON. And what do those increased user fees do, in your opinion, to your competitive posture.

Mr. GRIMES. I think they increase the competitive posture.

Mr. NELSON. OK, Mr. Savoca, and then I'll turn it over to my colleague, Mr. Walker.

NASA had agreed to sell your company the Delta hardware for approximately 87½ percent of what the Government paid for the hardware. Now, some at NASA indicate that if the hardware were not sold to TCI the Government might find another user for it, such as additional U.S. Government or foreign launches.

Now, here's the question. If the Government is to move to a policy of full-cost recovery for the shuttle launch services, what is your opinion as to the consistency or inconsistency of the policy of NASA to sell you the Delta hardware for less than it cost NASA to build that hardware?

Mr. SAVOCA. Well, I think the two are separate. If you're really asking, would we be willing to pay 100 percent for the hardware, if NASA went to full-cost recovery, the answer is yes, we would. I say the two are separate because our Nation made a decision to transition Delta launch vehicles to the private sector. NASA was charged with getting the best price, the market price they could get for that hardware, and the market price that we bargained for was 87—was 87½ percent. And I think it's more than a fair price.

Mr. **Nelson**. And when was that bargaining done, about 2 or 3 years ago?

Mr. **Savoca**. No, that bargaining was completed in about March of 1984.

Mr. **Nelson**. Mr. Walker.

Mr. **Walker**. Thank you, Mr. Chairman. Obviously both of you gentlemen have looked considerably at this full pricing policy. Let me give you a proposition, I don't have the power to do this, but if I did have the power to do it, let me give you a proposition. What if I were to give you the shuttle, right now, with no strings attached? What could you fly shuttle for per flight?

Mr. **Savoca**. If we—are you asking me, Mr. Walker?

Mr. **Walker**. Yes.

Mr. **Savoca**. If we were to recover full cost right now, which we would have to do, to recover full cost, I'll have to go back to that chart, but right now it would be somewhere in the neighborhood, in our estimation, of $530 or so million.

Mr. **Walker**. Well, if I've just given you the system——

Mr. **Savoca**. If you gave us the system?

Mr. **Walker**. If I gave you the system. Now, how much would it cost you to fly that system per flight, is what I'm asking you? Now, it's not going to cost you $530 million per flight.

Mr. **Savoca**. Well, I couldn't answer that question right now, but I'd be happy to provide you an answer. I'd have to—first of all, we don't have the full details of all of the NASA operational costs. We have scaled down versions that we got that was available through the—became public knowledge because of the September 17 submittal. It would be less than if we didn't have to recover our capital cost.

Mr. **Walker**. Well, obviously, I mean for instance there would be certain things—it would be less than your $150 million?

Mr. **Savoca**. I couldn't say whether it would be less than $150 million.

Mr. **Grimes**. Well, a fast analysis, if I could please, would be for the flight rate of 11 against our numbers that we just had on the board would be around $260 million per flight, for a flight rate of 11 missions per year.

Mr. **Walker**. Well, I'm a little confused by that figure. In other words the cost of the expendables and providing the launch service and everything would be $260 million, in your opinion, per flight?

Mr. **Grimes**. The cost of operating the Orbiter on an 11 flights per year basis would be that number.

Mr. **Walker**. What would be at 24?

Mr. **Grimes**. The number would be possibly in the order of $150 million.

Mr. **Walker**. $150 million, so in other words—in other words you're—now the $150 million that you had up there on the board included, for instance, depreciation of the vehicle.

Mr. **Grimes**. That's right.

Mr. **Walker**. And I just gave you the vehicle. So in other words, the depreciation, it seems to me, would at least have to come out of it, wouldn't it?

Mr. **Grimes**. That's right and I've pulled—I've pulled the depreciation out, sir.

Mr. **Walker**. But you still come back to the same figure you gave us originally.

Mr. **Savoca**. Well, I'm sorry, Congressman Walker, maybe I can straighten it out. What we said was that we would need a price of $150 million for a full shuttle payload bay price in order for our industry to be viable.

Mr. **Walker**. Well——

Mr. **Savoca**. The cost that we showed on the board had an average of $188 million. Now, when he pulled out the amortization of the Orbiter he took the $188 million and reduced it by the $15 million and he made some other reductions to get to $150 million.

Mr. **Walker**. OK, I understand what you're saying to me, but you see that has not been a market price that you're talking about. If we're talking about pricing the shuttle in a way that makes your industry viable, then that is not the free market at work.

Mr. **Savoca**. I agree with you.

Mr. **Walker**. You know, we don't have a responsibility in terms of shuttle pricing to price it in a way that makes you viable. That, in fact, subsidizes you at that point. It seems to me what we've got is a responsibility to equitably price the shuttle in the market place and you know that's what I'm trying to arrive at. Some determination that if in fact we were dealing with a real market price, what would that real market price be? And you know, I have a little hard time accepting, based upon the figures that you showed us today, that that real market price is the price that you quoted us for all of the add-ons that you priced. Including adding in the cost of all the defense missions and charging it to commercial customers.

Mr. **Savoca**. Well, I think maybe we're misunderstanding each other. I couldn't agree with you any more that what we, as business men are looking for, is a true cost—full-cost recovery, a marketplace price for shuttle.

Mr. **Walker**. And then——

Mr. **Savoca**. And that number would not be $188 million, it would be greater than that. We left out many things. We left out return on investment. We left out offset for taxes. We left out——

Mr. **Walker**. But all of those things I've just given you when I gave you the shuttle. I handed you the system. I gave you all those things.

Mr. **Savoca**. Then is that a true market price?

Mr. **Walker**. Then, I'm asking because in large part, you know, for instance you're paying 87½ cents on the dollar for the vehicle that you bought. That is the cost of production of that vehicle. It does not include all the R&D cost that, for instance, is in your $150 million for the shuttle.

Mr. **Savoca**. No, it does not.

Mr. **Walker**. Well, there's a portion—there's at least a portion of it in there when you charge off to NASA the stuff that we are essentially still flying as R&D stuff.

Mr. **Savoca**. The R&D costs were not part of the—of that price.

Mr. **Walker**. Well, it's my understanding, and correct me if I'm wrong, but the way in which you amortized the vehicle is in fact in a way that writes off all the cost of the vehicle against commercial customers.

Mr. Grimes. Just the pro rata share.

Mr. Savoca. That's the production cost of the vehicle, not the research and development cost that went into making it—that went into designing and developing that vehicle.

Mr. Walker. When you're writing off the NASA costs, are you writting off all the costs of the Agency?

Mr. Savoca. We're writing off on the basis of $1.5 billion manufactured cost for an Orbiter.

Mr. Walker. Yes, but the $1.5 billion does include a lot of R&D costs that are in it too.

Mr. Savoca. No, it does not.

Mr. Grimes. I believe that's the replacement cost.

Mr. Savoca. That's the replacement cost for the Orbiter and does not include research and development.

Mr. Walker. Well, you know, it would depend upon the definition of cost. I'm still a little bit confused as to how you can take a system that essentially is being handed to you and come up with the price that you've given me. Because as far as I know all the expendables, all the things that would go into that would be a price that would be far lower than the figure that you've given me. Unless the private sector operates more—at a greater cost than the public sector does, and I find that a little hard to believe as a free enterpriser.

Mr. Savoca. Well, if you take a look at what the operating cost of Delta was and compare it with the operating costs that we're talking about Delta now, we've made some efficiencies in the private sector. We have lost some ground in the private sector on a cost by cost basis. Where we lost ground is that the private sector has to make a rate of return, the private sector has to cover costs that were not covered when NASA was pricing the Delta launch vehicle. Rate of return being one of those.

Now, we can make efficiencies on the launch operations part of it. Our contract costs are higher because suppliers will want to make a greater return on investment commercially than they did when they had contracts with the Government.

Mr. Walker. Thank you, Mr. Chairman.

Mr. Nelson. OK, Mr. Andrews, of Texas.

[No response.]

Mr. Nelson. OK, we'll catch him when he comes back in.

Mr. Mineta.

Mr. Mineta. Thank you very much, Mr. Chairman.

Mr. Savoca, looking at your testimony on page 14, you indicate that there is ample room for use of the space shuttle, as well as development of the private ELV industry. And then you go on to say that the shuttle will be the only main reusable launch system to support the space station and other industries, expected to amount to revenues of about $60 billion by the year 2000. Now, what's at issue here though, is the pricing policy to be set in a period from 1989 to 1991 and that's short of the year that the space station is expected to be put into space. So, my question is, how can we then find an economical and reasonable policy which allows the ELV industry to flourish and support the shuttle until long-range uses can be realized.

Mr. SAVOCA. I—if I get the sense of your question properly what you're asking is, will the shuttle lose research and development costs, rather payloads, if the shuttle goes up, is that what you're asking?

Mr. MINETA. That's—because you're not going I mean the other figure that you're using is really going out to the year 2000. My question is, in the meantime where——

Mr. SAVOCA. Well, the existing policy allows for joint endeavor agreements, in other words subsidization of shuttle policy, I mean R&D payloads for shuttle, presumably as feed-ins to what would be required for the space platform, the existing policy allows for that and in fact encourages those agreements, and the full-cost recovery was meant to be against commercial and foreign launches only. So, the shuttle can continue to subsidize, charge anything for research and development payloads to encourage those. It's only—it is only the commercial satellite launches for commercial use and foreign use that we're seeking full cost recovery for.

Mr. MINETA. And has this, in any way, hurt U.S. ELV's in obtaining customers, as well as obtaining financing?

Mr. SAVOCA. Yes. The state of flux that we are in at the present time and the controversy over what was a stated policy of long standing. Full-cost recovery for the STS for foreign and commercial usage has been a policy of long standing. And the fact that now, you know, we're in the financial community with that known policy, before we entered the financial community, and now, all of a sudden, it is a controversy and there are all different—all different aspects of it, it is hurting our ability to obtain financing and it's hurting our ability in the marketplace as well.

Mr. MINETA. Can you explain to us a little bit more about the 301 filing against Ariane and what determinations still have to be made? How long will it take for the case to be resolved? And what recourse will our Government have if Ariane is indeed found to be engaging in unwarranted trade subsidies and where might this subcommittee help, or this committee?

Mr. SAVOCA. Yes. As I understand the process, and again, we filed the petition and we are now, in essence, an observer of the process, but we filed the petition, it was accepted in July of 1984 and by law the process must be completed 1 year later. So, by July 9, 1985 the process has to be completed. There have been, I think today makes the third consultation. There should be one going on today with the ESA nations and the policy—the procedure can be completed in a much lesser time if there is agreement between the parties to conclude it on a mutually satisfactory basis.

Now, the other part of your question was, what recourse does our Government—what recourse can our Government take if the ESA nations are not willing to give up their subsidy, and again, as I understand that, the U.S. Trade Representative will make a determination as to whether the allegations are true or otherwise. If they determine that they are true, and even if they determine that the ESA nations are not cooperating, and are withholding information, they then can make a recommendation to the President to apply sanctions, economic sanctions, against the offending nation, that would be more onerous to them than the issue at hand. If those sanctions then are adopted, why the pressure is there to increase the price.

Mr. MINETA. Could I then, Mr. Chairman, ask one quicky here. Aside then from the shuttle pricing issue and the Ariane trade issue that we just talked about being resolved, are there other activities that we might be undertaking to foster a greater ELV marketplace?

Mr. SAVOCA. Yes. I believe they are—there are. And those activities include, to start with, a cooperative team spirit of transition for this activity between NASA and the industries that are trying to transition the existing launch vehicles, rather than the spirit that seems to now exist, and that includes—that includes officials in public forums predicting that expendable launch vehicles will fail, and it also includes activities of that type, which certainly don't help the emerging expendable launch vehicle industry to find financing or give confidence to the marketing community that this Nation is really serious about trying to foster an expendable launch vehicle program. And we could work together, for example, in fostering a transition that takes into account any launches that NASA might have in the future, before we transition to the launch activity, and work together on those, so that we have a smooth transition process when we come to the end, that looks as if we have a very cooperative spirit.

Then finally, another activity that could take place, as you know the shuttle price has been subsidized up until 1989. We knew that as we entered the business. We accepted that and we are willing to continue to accept that. What that does to us, though, is it puts us in a loss position for the first few years, until the shuttle price goes to full-cost recovery, and our offering document in the financial world shows that. We are in a loss position until shuttle goes to full-cost recovery, and then we finally recoup.

Now, we have agreed to pay NASA 87½ percent of the hardware cost, and we have agreed to pay that as we use the hardware. Now, if this Government was serious in fostering this, one thing that could be done is that we could sign a note for the hardware when we use it, pay the current rate of interest for that hardware and pay, out of profit, the principal when the time came. So, that could be done and that could be a clear indication that we are serious as well.

Mr. MINETA. Mr. Chairman, is there a conflict between the Department of Transportation and NASA in this regard then? That's built in, that makes that fostering on one hand versus the operational and pricing on the other a conflict in itself?

Mr. NELSON. I would suggest that you draw some conclusions once you hear from the Agency's testimony, which we're going to have. Both of those Agencies testify at our next hearing on this issue, which is March 5.

Mr. MINETA. I'll wait, Mr. Chairman.

Mr. NELSON. All right. Mr. Smith.

Mr. SMITH. No questions at this time, Mr. Chairman.

Mr. NELSON. Mr. Volkmer.

Mr. VOLKMER. Thank you very much, Mr. Chairman.

I'd like to ask both Mr. Scherer and Mr. Savoca a question and I'd like both of you to reply to it. You can do it in the order which you determine yourself. That is: Recently, according to information that I have heard, the NASA projections on numbers of satellites and launch use have been reduced from where they were 2 or 3 years ago for the same time period, and I'm talking about through 1988, 1991, 1994, through those time periods, that they're reducing those on their estimates that they're not going to be as high as they thought they were. I'd like to know what you think about that.

Dr. SCHERER. We'll let Mr. Savoca rest for a moment, sir. I think the trend is as you say and it's 2 or 3 years ago we made a prediction of the possibility of market capture of some 240 commercial payload over a 10-year period. Excluding those that politically or otherwise would go to Ariane automatically we assumed there were 201 was the number that we came up with. Our current prediction is 180 of those, instead of 201, so that's the degree of the change.

One of the big reasons is that the direct broadcast satellite business, which was thought to—would be exploded, has not. Some people have dropped out, or I think most of them are just delaying, trying to see who's going to go first in that business, and that accounts for a large number of—of a great amount of the difference.

However, I would point out that at this current moment there are some 25 companies with 80—with proposals for 82 satellites sitting in the FCC, waiting for their judgment on it.

Mr. VOLKMER. Now, Mr. Scherer, as long as you started, I'm going to ask you the second question first, before we hear from Mr. Savoca. And that is in that regard also, do you see any change in the size of the satellites. In other words, the growth of the satellites, that was addressed before from around the 2,000 pound payload, up to the 4,000 or 5,000 pound payload.

Dr. SCHERER. Yes, sir. I see some differences. I think the smaller ones, which were the basic Delta size, there's a trend that they're slowly growing and TCI has stated that the Delta can grow also. They're trying a PAM-B size for the shuttle bay, which is around 2,800 pounds. There seems to be a movement toward the PAM-B-II size of about 4,200 pounds. But, in general the spacecraft owners are trying to put as much of their—the system—make it as viable as they can by increasing the lifetime, as a big reason for the weight growing. The Atlas/Centaur size spacecraft, which would be from 4,000 pounds to 5,200 with a basic Atlas/Centaur, with the customers we've talked to, they're now looking at 5,600 hundred pounds as kind of an average, as part of this example of growth.

On the other side of the coin, we estimated 1½ years ago that the—that 12 percent of the payloads would be larger than Atlas/Centaur capability, and when I say that I'm talking about 5,600 pounds. The current estimate is 4 percent will be larger. Intelsat was going to build a large number of Intelsat-6's and they cut their number way down on that total. At least some parts of Intelsat has suggested they go back to Intelsat-5 size, which is Atlas/Centaur size.

So, there are plans, but they're kind of in several different directions.

Mr. **Volkmer**. All right. And along those lines the PAM–B–II is operational on the shuttle, is the PAM–B–II operational on the Delta?

Mr. **Savoca**. No.

Mr. **Volkmer**. Could it be made that way? Could you lift that much with—could you fit it on——

Mr. **Grimes**. I don't know, actually the PAM–B itself is a very efficient third stage for Delta payloads, all the way up to about 5,500 pounds, so it just really doesn't fit the Delta configuration as a third stage.

Mr. **Volkmer**. Mr. Savoca, do you wish to answer the first question about the estimate?

Mr. **Savoca**. Yes, sir. I will and I'll try to make it as brief as I can. As we see all of the answers in the market today, at this very moment in time, we're confused first, why they're all there and it seems as if market arguments are being made to support whatever position has to be supported at the particular time. I'll give you an example. Two or 3 months ago, almost everybody was predicting a large market, and there was some fluctuation, but almost everybody was predicting a large market. Now that the shuttle pricing issue has become very, very current there are many now saying that there is a small market, but what we see that has happened in the market assessment is that not all that much changed. First of all almost everybody bases their basic input on the Batelle study and then they jockey that around, using direct interface with the market, as we have done. Now, the near term, in the near term, if you take the manifest of launches that are scheduled, in the near term you see that the manifest is increasing from 20 launches in 1985 to 26 in 1987, so that shows an increase there.

If you take NASA's pricing policy for the 3 years, and they say in 1990 and 1991 that they are going to devote 4.2 launches to commercial and foreign satellite launches. Now, if you equate that to Delta payloads and use the conversion factor, that's 21 Delta class payloads and of course their market estimate is always based on capturing 75 percent of the market, so they're saying that equates to 28 Delta class payloads.

Then NASA did a transponder study, which was completed in November of 1984, in that the transponder study says that the Transponder demand is increasing, although not as at a rapid a rate as it was with the previous study. Hughes did a paper in 1983, in the world telecommunications forum and that was December of 1983, recently, and there they forecast a foreign satellite market as accelerating very, very rapidly. As Lee pointed out there are 21 applications now before the FCC and those cover 85 spacecraft. And going to two degree spacing and colocations of different bands of satellites have increased the amount of positions from 32 to 62 and then, of course, the technology to further increase that is more than keeping pace with the satellites that are going to be launched. So, the antenna technology and the frequency technology is keeping pace.

Now then, finally, the market only includes forecast for communications, weather, and Earth resources satellites, those are only applications that are known today, and almost everybody would agree that future development in this market for applications that are not known is yet to come. And not only that, the economic factors that exist will be a high incentive as to what is developed and how it is developed. And so that's another reason to make sure that when we're starting this new industry, and it is the apex of other industries to start in space, that we create an economic world that fosters earnings on a logical basis, that applies the resources in a logical way, rather than to try to get everybody on a subsidy of one kind or another, pretty soon you have an interlocking ball that can't—that can't possibly be solved. And so that's our assessment of it.

Mr. VOLKMER. Basically what I hear—Chairman, I know my time is up, but I'd like to see if I can clarify in my mind what you said. What I hear you saying is that based on existing technology, and the satellites that we have and the existing technology, that you still believe that there will be a sufficient growth in there to provide not only for, and you correct me if I'm wrong, utilization of the shuttle in the 1988, 1989, 1991 timeframe, which we're projecting 24 launches a year, plus Ariane, by that time they should have their second launch pad, and as I understand it, 17 launches per year, and that's 41 launches per year with the utilization of those two, you say you believe there will be additional need beyond that?

Mr. SAVOCA. Yes, sir, we do.

Mr. VOLKMER. Beyond 41 per year?

Mr. SAVOCA. Well, beyond 41 per year? At some point in time there will be. You know, I'm not ready to give Ariane the launch capability that they ascribe to themselves. If you analyze Ariane's schedule and their manifest, what they are launching on is an ever-changing vehicle, when they go to Ariane-4, they're changing configuration with almost every flight, and yet they're decreasing time between launches drastically as they go along.

Now, our country has not been able to do that with a vehicle that's pretty stable and I don't think Ariane will be able to do that either.

Mr. VOLKMER. Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Volkmer. Mr. Monson.

Mr. MONSON. I'd like to ask you if you could swap places with us and set the policy, what you deem would be the appropriate policy for Federal Government in space and include in that what it should be in regards to launch services and also to space commercialization?

Mr. SAVOCA. Well, if you're asking me what I think the total Federal role in space ought to be, I'll answer in this way. I think that NASA has been given a task to account for costs on a return basis, which I don't think they should be saddled with. I think the role in space for the United States is to do those things militarily that we must do, and then to foster the technology that has to be fostered in order to insure the well being of this Nation and other humans in the world.

Now, because of the tremendous cost of flying the research and development payloads until they get proved out, those things might have to be subsidized at the time. You said change places with you, what I would do if I changed places with you, or what I would try to do, would be to go ahead and make the assessments on what this Nation needs to spend in space and not hold NASA's feet to the fire to show a return. They have to meet their budget, but not to show—not to show a return from commercial activities. And as companies became subsidized in their research and development activities for commercial products, to strike a bargain with them, so that they would have a—so that they would pay a subsidy to the United—not a subsidy, I'm sorry, a royalty to the U.S. Government from any product that came in space.

Now, if we did that, space is no different a medium than almost any other and we're right at the—right at the point of it now and there will be many products that get developed in space. If we did that, in several years or a few years, 10, 15, maybe 20, the entire space program of the United States would be paid from royalties from that kind of seed money.

Mr. MONSON. Dr. Scherer, do you have any additional——

Dr. SCHERER. I think Mr. Savoca covered it quite well, sir. I, as a man who had a long tour in NASA, I am disturbed by something that I perceive, which may or may not be true, but there seems to be a lot of interest in, or there seems to be something that makes NASA feel that they'll be judged on the number of commercial payloads that they will recover—capture. And I think—I think this is wrong. NASA is our No. 1 R&D scientific outfit in this country and I don't think that this emphasis should be there, if it is, and I cannot—I'm not sure of that. If I were in your position, if I were making this policy, and I can only speak personally, certainly General Dynamics is not—it's not their business to come up with such judgment, the country decided to commercialize ELV's for what were apparently good and sufficient reasons, and now we find ourselves in this peculiar dichotomy of the Government competing with commercial. I think the—as I say in the statement, I think it's—we should let the free market determine it. You need to understand the shuttle cost, and all the shuttle costs, the true shuttle costs, to make judgments on the number of launches that are a reasonable number and that will arrive at—that will give you a shuttle cost that the commercial and foreign satellites should pay. It's the same policy we used at NASA forever with ELV's.

I think I launched some 60 or something of them. They paid every possible cost we could figure out in this formula that we had. And then it changed—it didn't really change. Initially we, and I can say that as NASA, we attempted to set a price that was a little lower than we thought the cost would be and over a 12-year period it would be a little higher than we thought the cost would be because of the learning curve and there would have been no price supports for foreign and commercial over that 12-year period. Now we're a lot smarter now in what it takes to operate the shuttle and those number have gone up, but the policy has been the same.

In terms of emerging industries I'm for all the support we can give them. This is certainly part of NASA's basic R&D charter. And the joint endeavors, some strong price support for development size, going from research to development, but what we—when they get into the full commercial phase, however that's judged, and I don't think it would be easy to judge that necessarily, when they're out trying to make a profit, then I think they should pay the transportation costs, whatever those may be, unless there's some overriding national interest because of the type of product that's coming out.

Mr. Monson. Thank you.

Mr. Nelson. Any questions from our colleague from Kansas?

Mr. Meyers. No, Mr. Chairman, no questions.

Mr. Nelson. Mr. Slaughter?

Mr. Slaughter. No questions.

Mr. Nelson. If not then we'll have our panel convene and I want to thank you very much for your comments.

We have the panel on communication satellite builders and operators, please. Is the user panel—let's with the greatest of expedition see if we can move.

We have Dr. Robert Roney, from Hughes Aircraft, Michael Lyons, from Satellite Business Systems, they are from the communication satellite builders and operators.

From upper stage manufacturers, we have Charles Ordahl, from McDonnell Douglas, David Thompson from Orbital Sciences Corp.

Then from space platform builders and operators we have Dr. John Townsend, from Fairchild.

And material processing companies, we have James Rose, who is also from McDonnell Douglas.

All right, let's just take you all in that order in which I read out. We appreciate your being here very much, welcome and please proceed, Dr. Roney.

STATEMENT OF DR. ROBERT K. RONEY, VICE PRESIDENT, HUGHES AIRCRAFT CO.

Dr. Roney. Thank you, Chairman Nelson.

Mr. Nelson. And might I say, if you all have a lengthly statement, we've already run over, as you can imagine, considerably, we will submit your statement. It will be printed in full in the record and if you would like to summarize it for us, making the salient points that you want, you are welcome to do so.

Dr. Roney. I'll try to keep mine to 10 minutes.

Chairman Nelson, members of the committee, ladies and gentlemen, I am very pleased for this opportunity to speak to you today, and to give my views on shuttle pricing policy from the perspective of a user who both builds and operates communication satellites.

First; let me say we are very sympathetic with the interest in promoting the free enterprise commercialization of space. In fact, the commercialization of space is not a new concept. It began 20 years ago with the first commercial satellite, and since that time has grown into a multibillion-dollar industry with billions of dollars of assets in space, yielding nearly $1 billion per annum in revenues to American manufacturers alone, with comparable amounts for space transportation and for value added services by communications operators. Nearly 40 percent of those spacecraft sales are into the export trade. Now, spacecraft is one of the few markets in which the United States still enjoys a favorable balance of trade for manufactured products.

This flourishing business has been nurtured by the relatively economical access to space provided by NASA over these 20 years. In recent years NASA has faced foreign competition in space transportation, which, though directly adversely affecting the U.S. trade balance, has overall been stimulative to the communication satellite market by slowing the upward spiral of space transportation costs.

As both a builder and operator of communications satellites, my company is keenly interested in anything that affects the economy of satellite communications. Thus we welcome the prospect of American commercial ELV services. But, we are deeply concerned that in the interest of promoting an emerging commercial space enterprise the Government may adopt policies that could strangle the existing thriving enterprise.

The cost of transportation accounts typically for about half the total cost—total capital cost of a communication satellite. Thus the economics of satellite communications is vitally sensitive to the cost of launches. For the purpose of the communications satellite traffic, the viability of a space tranportation system hinges not only on its pricing relative to alternative transportation systems, but also relative to the cost of alternative communications technology other than satellite.

By way of illustration, a standard commodity unit in the satellite communications today has become the fully backed-up C-band transponder in the U.S. domestic service. This unit is facing considerable market resistance at a $6 million sales price. Every $50 million increase in the transportation cost of a dedicated shuttle will add $1 million to the cost of that transponder. It is impossible to say at what transportation cost the satellite market would totally disappear, as different elements of the market will have different break points, but it is clearly an elastic market. Even today some markets in which satellites have heretofore prospered are showing increasing competition from terrestrial means, especially with the growing capabilities of fiber optics.

So, where does that bring me regarding shuttle pricing policy. Well, it should be clear that communications operations need the lowest price that is practicable. This interest must be reconciled with the public interest of full recovery of launch services cost. The issue then is; what costs are to be fully recovered? For purposes of commercial satellite launches, I submit that the costs to be fully recovered should be the additive costs for the commercial mission. I base this position on two arguments:

The first argument is one of fairness. That is, much of the cost of operating the shuttle system stems from its status as our national manned flight vehicle. I detect no perception among communications operators of any operational advantage to them from the special characteristics of the shuttle. In fact, on the whole, the operational problems of using the shuttle have a negative appeal relative to the convenience of a dedicated expendable booster. So, it is unfair to charge any of the cost of maintaining the manned spaceflight program for the service of simply transporting a payload to orbit.

The second argument is one of public interest. First we must decide as a matter of national policy why we want a Shuttle Program, and why it matters whether it beats the ELV's, either foreign or domestic.

Do we need the shuttle for, one, its fundamental capabilities not attainable with ELV, that is, for a national objective not justified simply on utilitarian economic grounds? or two, do we need it for its superior economy for space transportation? If it is the latter, then the continuation of the Shuttle Program must stand on the validity of that proposition. Its economy would be tested by the absorption of all costs associated with its operation by charges for cargo transportation.

But if, as I believe, our purpose for the STS is to serve national objectives related to its fundamental characteristics, a matter of national pride, of man in space, research into the unknown, a step toward the space station and beyond, then the justification for existence and maintenance of its basic capability has nothing to do with relative economy. Its basic cost will be incurred and justified for that purpose without regard to any routine transportation traffic. It then certainly becomes appropriate to consider additional, nonnational uses simply on the basis of whether that use is marginally economic.

If it is not marginally economic, such additional business should be allowed to go wherever the economics dictate.

On the other hand if the market, as constrained by demand elasticity or competitive launch vehicles, will support a price above the additive costs, use of the shuttle should be priced competitively to that market so as to maximize the product of the payloads captured and the marginal return. This will maximize the total net return to the taxpayer or minimize the unrecovered cost of the Shuttle Program.

It is beyond my competence to settle just where that price will be, but I am sure it must be well below the so called full recovery of all shuttle operating costs, especially in the event NASA falls short of its launch rate goal. That optimum price will also likely be below the price of the equivalent ELV, for as I have said, on the whole, the operational problems of the shuttle have a negative appeal relative to ELV's. The overwhelming positive appeal of the shuttle has lain in its price advantage, relative to alternative launchers for the commercial launches. Commercial success of the STS hinges on continuation of this margin.

This concludes my statement. I thank you for the opportunity to give my views.

[The prepared statement of Dr. Roney follows:]

PREPARED STATMENT BY ROBERT K. RONEY, VICE PRESIDENT, HUGHES AIRCRAFT CO.

Chairman Nelson, members of the Committee, ladies and gentlemen: I am very pleased for this opportunity to speak to you today, and to give my views on Shuttle pricing policy from the perspective of a user who both builds and operates communications satellites

First, let me say we are very sympathetic with the interest in promoting the free enterprise commercialization of space. In fact, the commercialization of space is not a new concept. It began 20 years ago with the first commercial ~~communications~~ satellite, Early Bird. Since that time it has grown to a multi-billion dollar industry with billions of dollars in space assets, yielding nearly $1 billion per annum in revenues to American spacecraft manufacturers alone, with comparable amounts for space transportation and for value added services by communications operators. Nearly 40% of these spacecraft sales are into the export trade. Spacecraft is one of the few markets in which the United States enjoys a favorable balance of trade for manufactured products.

This flourishing business has been nurtured by the relatively economical access to space provided by NASA over these 20 years. In recent years NASA has faced foreign competition in space transportation, which, though directly adversely affecting the U.S. trade balance, has overall been stimulative to the communication satellite market by slowing the upward spiral of space transportation costs.

As both a builder and operator of communications satellites, my company is keenly interested in anything that affects the economy of satellite communications. Thus we welcome the prospect of American commercial ELV services. But we are deeply concerned that in the interest of promoting an emerging commercial space enterprise the government may adopt policies that could strangle an existing thriving enterprise.

The cost of transportation accounts typically for about one half the total capital cost of a communication satellite. Thus the economics of satellite communications is vitally sensitive to the cost of launches. For the purposes of the communications satellite traffic, the viability of any space transportation system hinges not only on its pricing relative to alternative transportation systems, but also relative to the cost of alternative communications technology.

By way of illustration, a standard commodity unit of satellite communications today has become the fully backed-up 36 mhz C-band transponder in the U. S. domestic service. This unit is facing considerable market resistance at a $6 million sales price. Every $50 million increase in transportation cost of a dedicated shuttle will add $1 million to the cost at that transponder. It is impossible to say at what transportation cost the satellite market would totally disappear, as different elements of the market will have different break points, but it is clearly an elastic market. Even today some markets in which satellites have heretofore prospered are showing increasing competition from terrestrial means, especially with the growing capabilities of fiber optics.

So, where does that bring me regarding shuttle pricing policy? It should be clear that communications operations need the lowest price that is practicable. This interest must be reconciled with the public interest in "full recovery" of launch services cost. The issue is; what costs are to be fully recovered? For purposes of commercial satellite launches, I submit that the costs to be "fully recovered" should be the additive costs for the commercial mission. I base this position on two arguments:

The first argument is one of fairness. That is, much of the cost of operating the shuttle stems from its status as a manned flight vehicle. I have detected no perception among communications operators of any operational advantage from the special characteristics of the shuttle. In fact, on the whole, the operational problems of using the shuttle have a negative appeal relative to the convenience of a dedicated expendable rocket. So it is unfair to charge any of the cost of maintaining the manned spaceflight program for the service of simply transporting a payload to orbit.

The second argument is one of the public interest. First we must decide as a matter of national policy why we want the shuttle program, and why it matters whether it beats the ELVs, either foreign or domestic.

Do we need the shuttle for (a) its fundamental capabilities not attainable from an ELV, i.e., for a national objective not justified simply on utilitarian economic grounds?; or (b) do we need it for its superior economy for space transportation? If it is the latter, then continuation of the shuttle program must stand on the validity of that proposition. Its economy would be tested by absorption of all cost associated with its operation by charges for cargo transportation.

If, as I believe, our purpose for the STS is to serve national objectives related to its fundamental characteristics, a matter of national pride, of man in space, research into the unknown, a step toward the space station and beyond, then the justification for existence and maintenance of the basic capability has nothing to do with relative economy. Its basic cost will be incurred and justified for that purpose without regard to any routine transportation traffic. It then certainly becomes appropriate to consider additional, non-national uses simply on the basis of whether that use is marginally economic.

If it is not marginally economic, such additional business should be allowed to go where the economics dictate.

On the other hand, if the market, as constrained by demand elasticity or competitive launch vehicles, will support a price above the additive costs, use of the shuttle should be priced competitively to that market so as to maximize the product of payloads captured times the marginal return. This will maximize the total net return to the tax payer, or minimize the unrecovered cost of the shuttle program.

It is beyond my competence to settle where that price will be, but I am sure it must be well below the so called "full recovery" of all shuttle operating costs, especially in the event NASA falls short of its launch rate goal. That optimum price will also likely be below the price of an equivalent ELV, for as I have said, on the whole, the operational problems in using STS have a negative appeal as compared with the convenience of a dedicated expendable launcher. The overwhelming positive appeal of the shuttle has lain in its price advantage, relative to alternative launchers. Commercial success of the STS hinges on continuation of this margin.

This concludes my statement. I thank you for this opportunity to give my views.

Mr. NELSON. Thank you, Dr. Roney.
Mr. Lyons, SBS.

STATEMENT OF MICHAEL T. LYONS, VICE PRESIDENT AND GENERAL MANAGER, SPACE RESOURCES DIVISION, SATELLITE BUSINESS SYSTEMS

Mr. LYONS. Thank you, Mr. Chairman, and members of the subcommittee.

On behalf of Satellite Business Systems, thank you for the opportunity to share with the subcommittee our opinions on pricing policy for the STS. SBS has a profound interest in the direction of the U.S. Government policy decision regarding the Government and commercial launch services.

SBS is a nationwide and international communications company owned by IBM and Aetna Life and Casualty. In fulfilling our corporate role we have been, and will continue to be, a major user of launch services. SBS has four satellites in orbit. Two employed the Delta launch vehicle and two employed the STS. In fact, the SBS-3 satellite was the first operational satellite deployed by the shuttle. All of our launches have been totally sucessful and we are understandably enthusiastic about the quality and reliability of the NASA launch organizations. SBS has developed a special perspective on the evaluation of different launch systems, based on these past experiences and on our more recent experience in negotiating a launch contract for our fifth spacecraft, and in our current negotiations on our sixth spacecraft launch.

From an operational point of view, the STS vehicle is the primary workhorse which SBS would prefer to depend upon to provide its spacecraft transportation to orbit. We prefer this vehicle because of our assessment of its reliability and, flexibility, and because of the quality of the team that provides launch services for the spacecraft, and because of our pride in our national resource.

Notwithstanding the SBS operational preference for the STS as its primary vehicle, we endorse the need for an alternative vehicle. In support of this consideration, we elected to employ the Ariane vehicle for our fifth launch, with the STS as a potential backup. SBS selected Ariane principally due to a concern with balancing the risk and minimizing the dependence upon a single launch vehicle to provide the much needed communications capacity in the 1986–87 timeframe.

In the process of selecting the Ariane launch vehicle in April of 1984, SBS had an opportunity to assess the relative benefits of the STS, Ariane, and the Delta vehicle, as provided by Transpace Carriers. At the time of that competition the Ariane and the Transpace Delta were directly competitive with each other with respect to price, and the STS was significantly higher. While price was not the primary motivation in SBS's decision to select the Ariane, it was certainly a significant factor. Although the Transpace price was directly competitive with that of Ariane, the price was contingent upon Transpace being able to obtain two additional users of the Delta vehicle in order to assure a viable program. SBS has flown the Delta vehicle on two occasions and has an extremely high regard for the quality of the vehicle, and of the operating team which Transpace was proposing to employ for the launch. However, in recognizing the absolute requirement for SBS to be able to formulate a firm business plan with fixed cost and schedules for delivery of the desired communications capacity in a timely manner, the Transpace offer was deemed substantially less attractive than that of Ariane.

It is our belief that long-term institutional backing and the assurance of a reasonable annual launch rate are essential to the establishment of commercial viability, and appeal, for commercial expendable launch vehicles. As an example of the type of institutional backing that is now available, the Ariane-3 vehicle is currently being provided by Arianspace, and the larger capacity Ariane-4 vehicle will be flown in 1986. In addition, Arianespace in conjunction with the French Government, is sponsoring an Ariane-5 development. Thus there is a sustained program by Arianespace to meet both the current and future needs of the user community. This has, in fact, established a base against which others will be compared.

This brings us to the remaining, but substantial, issue of price. Reliability and availability are prerequisite criteria for choosing a particular launch vehicle, but price has an even broader impact. The prices of different launch services obviously helps a customer decide which one to buy. In addition, however, the price of a launch service also plays a major role in encouraging or discouraging the commercial development and use of outer space.

In the telecommunications area, for example, this happens to be a particularly critical time when companies are looking at the relative merits and costs of future investments in satellites or terrestrial facilities. In our view, at the present time, the relevant costs in many areas are roughly comparable or generally balance. However, an artificial increase in the costs of launch, especially if not tied to the real costs or to an increase in the value of the service, could well have a significant adverse impact on the case for using outer space. This bias could apply in other areas as well, such as scientific and product manufacturing activities.

It is, therefore, extremely important that any changes in Government policy on launch pricing should take into full account the potential impact on the future commercial development of outer space resources, as well as the impact on the relative competitive positions of different launch vehicles and services. Neither the Government nor industry can afford to be shortsighted in this regard. The outcome of the current debate on launch pricing will, in fact, have consequences far beyond the choice of launch services; it will affect the basic decision whether to launch at all. This pricing policy decision is, therefore, tied closely to the public policy on encouraging the development and use of the resources of outer space.

SBS has raised these considerations in conversations with Government officials who are participating in this policy review. In addition, we are actively participating as a member of the Commercial Space Transportation Advisory Committee of the Department of Transportation. The staff and members of that committee have initially focused on the roles and present costs of the STS and existing expendables. We believe it is now equally important to focus as well on the impact of pricing changes on the user community, which, after all, is going to be the basis for commercial viability of these vehicles. We have submitted a letter to the Department of Transportation expressing our concerns. Our letter, of November 12, 1984, is being submitted as part of the SBS written statement.

Based upon the above considerations, it is our strong recommendation that the STS price be established at a level consistent with recovery of the additive costs of the launch service. In proposing this price structure, we are reflecting the basic realities of the STS program; it is a national resource, and for the United States to pursue its space-related objectives, the STS will be funded as an operational system. As a consequence, there is a fixed minimum annual funding level associated with sustaining the operational, engineering, and training efforts. SBS does not believe it appropriate that commercial STS users should bear these costs. We do, however, agree that we and other users should share proportionally all costs directly associated with the specific flight. These costs would include NASA engineering support, all consumables and expendables, and direct mission support.

It is SBS's belief that a proper accounting of these costs will yield an STS launch price that fairly recovers the U.S. Government investment, and would allow the STS to be competitive with alternative foreign launch vehicles, such as Ariane. In addition, it would establish a fair market base on which other expendable launch services could measure their own competitive viability.

We further believe that this policy is most consistent with maintaining the United States as the world space leader, and providing for the U.S. people the maximum opportunities and benefits of space research and commercial space operations. Thank you, Mr. Chairman, for this opportunity.

[The prepared statement of Mr. Lyons follows:]

STATEMENT OF MICHAEL T. LYONS
VICE PRESIDENT & GENERAL MANAGER
SPACE RESOURCES DIVISION
SATELLITE BUSINESS SYSTEMS

Before the
Subcommittee on Space Science and Applications Committee
on Science and Technology
United States House of Representatives
February 21, 1985

On behalf of Satellite Business Systems (SBS), thank you for the opportunity to share with the Subcommittee our opinions on pricing policy for the Space Transportation System (STS). SBS has a profound interest in the direction of U.S. Government policy decisions regarding Government and commercial launch services.

SBS is a nationwide and international communications company owned by IBM and Aetna Life and Casualty. In fulfilling our corporate role we have been, and will continue to be, a major user of launch services. SBS has four satellites in orbit; two employed the Delta launch vehicle and two employed the STS. In fact, the SBS-3 satellite was the first operational satellite deployed by the STS. All of our launches have been totally successful and we are understandably enthusiastic about the quality and reliability of the NASA launch organizations. SBS has developed a special perspective on the evaluation of different launch systems, based on these past experiences, on our more recent experience in negotiating a launch contract for our fifth spacecraft, and on our current negotiations on our sixth spacecraft launch.

From an operational point of view, the STS vehicle is the primary workhorse which SBS would prefer to depend upon to provide its spacecraft transportation to orbit. We prefer this vehicle because of our assessment of its reliability and, flexibility, because of the quality of the team that provides launch services for the spacecraft, and because of our pride in this national resource.

Notwithstanding the SBS operational preference for the STS as its primary vehicle, we endorse the need for an alternative vehicle. In support of this consideration, we elected to employ the Ariane vehicle for our fifth launch, with the STS as a potential backup. SBS selected Ariane principally due to a concern with balancing the risk and minimizing the dependency upon a single launch vehicle to provide much needed capacity in the 1986/87 timeframe.

In the process of selecting the Ariane launch vehicle in April of 1984, SBS had an opportunity to assess the relative benefits of the STS, Ariane and the Delta vehicle, as provided by Transpace Carriers, Inc. At the time of that competition the Ariane and the Transpace Delta were directly competitive with each other with respect to price, and the STS was significantly higher. While price was not the primary motivation in SBS's decision to select the Ariane, it was certainly a significant factor. Although the Transpace price was directly competitive with that of Ariane, the price was contingent upon Transpace being able to obtain two additional users of the Delta vehicle in order to assure a viable program. SBS has flown the Delta vehicle on two occasions and has an extremely high regard for the quality of the vehicle, and of the operating team which Transpace was proposing to employ for the launch. However, recognizing the absolute requirement for SBS to be able to formulate a firm business plan with fixed cost and schedules for the delivery of the desired communications capacity in a timely manner, the Transpace offer was deemed substantially less attractive than that of Ariane.

It is our belief that long term institutional backing and the assurance of a reasonable annual launch rate are essential to the establishment of commercial viability, and appeal, for commercial expendables. As an example of the type of institutional backing that is now available, the Ariane 3 vehicle is currently being provided by Arianespace, and the larger capacity Ariane 4 vehicle will be flown in 1986. In addition, Arianespace, in conjunction with the French Government, is sponsoring an Ariane 5 development. Thus there is sustained program by Arianespace to meet both the current and future needs of the user community. This has, in fact, established a base against which others will be compared.

This brings us to the remaining, but substantial, issue of price. Reliability and availability are prerequisite criteria for choosing a particular launch vehicle, but price has an even broader impact. The prices of different launch services obviously helps a customer decide which one to buy. In addition, however, the price of launch services also plays a major role in encouraging or discouraging the commercial development and use of outer space.

In the telecommunications area, for example, this happens to be a particularly critical time when companies are looking at the relative merits and costs of future investments in satellites or terrestrial facilities. In our view, at the present time the relevant costs in many areas are roughly comparable or generally balance. However, an artificial increase in the costs of launch, especially if it is not tied to the real costs or to an increase in the value of the service, could well have a significant adverse impact on the case for using outer space. This bias could apply in other areas as well, such as scientific and product manufacturing activities.

It is, therefore, extremely important that any changes in Government policy on launch pricing should take into full account the potential impact on the future commercial development of outer space resources, as well as the impact on the relative competitive positions of different launch vehicles and services. Neither the Government nor industry can afford to be short sighted in this regard. The outcome of the current debate on launch pricing will, in fact, have consequences far beyond the choice of launch services; it will affect the basic decision whether to launch at all. This pricing policy decision is, therefore, tied closely to the public policy on encouraging the development and use of the resources of outer space.

SBS has raised these considerations in conversations with Government officials who are participating in this policy review. In addition, we are actively participating as a member of the Commercial Space Transportation Advisory Committee of the Department of Transportation. The staff and members of that Committee have initially focussed on the roles and present costs of the STS and existing expendables. We believe it is now equally important to focus as well on the impact of pricing changes on the user community, which, after all, is going to be the basis for commercial viability of any of these vehicles. We have submitted a letter to the Department of Transportation expressing our concerns. Our letter, of November 12, 1984 is being submitted as part of the SBS written statement.

Based upon the above considerations, it is our strong recommendation that the STS price be established at a level consistent with the recovery of the additive costs of the launch service. In proposing this price structure, we are reflecting the basic realities of the STS program; it is a national resource, and for the United States to pursue its space related objectives, the STS will be funded as an operational system. As a consequence, there is a fixed minimum annual funding level associated with sustaining the operational, engineering and training efforts. SBS does not believe it appropriate that commercial STS users should bear these costs. We do, however, agree that we and other users should share proportionally all costs directly associated with the specific flight. These costs would include NASA engineering support, all consumables and expendables, and direct mission support.

It is SBS's belief that a proper accounting of these costs will yield an STS launch price that fairly recovers the U.S. Government investment, and would allow the STS to be competitive with alternative foreign launch vehicles such as the Ariane. In addition, it would establish a fair market base on which other expendable launch services could measure their own competitive viability.

We further believe that this policy is most consistent with maintaining the United States as the world space leader, and providing for the U.S. people the maximum opportunities and benefits of space research and commercial space operations. Thank you Mr. Chairman for this opportunity to express our views.

Letter Dated November 12, 1984
To The Honorable Elizabeth Hanford Dole
Department of Transportation

SBS

SATELLITE BUSINESS SYSTEMS 8283 GREENSBORO DRIVE, McLEAN, VIRGINIA 22102 (703) 442-5022; Telex/TWX 710-833-0322

RONALD F. STOWE
Vice President
Government & Commercial Affairs

November 12, 1984

The Honorable Elizabeth Hanford Dole
Secretary of Transportation
400 7th Street, S.W.
Washington, D.C. 20590

Dear Madame Secretary:

As a member of your Commercial Space Transportation Advisory Committee, I was pleased to participate in the first round of discussions which were held at the Department October 22 and 23, and I would like to commend the staff of the Office of Commercial Space Transportation for their efficiency and thoroughness in presenting the initial set of issues and reports. Government decisions regarding future commercial space launch policy can have a profound effect in many areas, and we believe that the establishment of this Advisory Committee can be a very useful means of obtaining views from the private sector.

As you may be aware, Satellite Business Systems is a major user of launch services. We now have four Ku-band domestic communications satellites in orbit and we are authorized to launch our fifth in 1986. We have utilized two U.S. manufacturered expendables, and two flights of the Space Shuttle. We are now under contract with Arianespace for our fifth launch. Beginning in 1987 we will initiate a replacement program for those spacecraft, and we are developing plans for the launch of larger and more sophisticated satellites in the 1990's. We, and the growing number of other satellite service providers, and in turn our customers, have a substantial interest in the development of sound launch policies in this country.

You have by now received a report by Mr. Mossinghoff, the Chairman of our October session, reflecting the initial discussions and recommendations. Because time was quite limited, particularly for dealing with such complex issues, we look forward to revisiting some of those questions in greater detail at future sessions.

As the Department plans the agenda for the next meeting of the Committee, it is extremely important to focus on the effect of a U.S. Government sponsored launch policy on commercial satellite operators and the customers they serve, as well as on those who will offer the actual launch service. The costs, reliability, timely availability, and related terms and conditions of launch services are substantial factors in the commercial viability of satellite-based services and in their affordability to customers, both of which are key elements of the general public interests at stake. A significant increase in launch costs or significant decrease in reliability, for example, could result in driving U.S. commercial satellite operators toward foreign launch providers, or an imbalance in favor of terrestrial rather than satellite transmission facilities. Neither result would be in the public interest.

For these reasons, we believe the Advisory Committee's agenda, and the scope of the Department's policy review, must be expanded well beyond the issues raised at the October session. Quite frankly, it is a substantial concern to us and to other carriers with whom we have consulted that the effects referenced above were not addressed as critical basic policy factors. The primary thrust of the staff and of the Committee's initial work was properly to examine conditions for commercial ELV viability, but it must be remembered that those conditions are influenced not only by the availability of the STS and foreign launch services, but equally by the economic and operational appeal of those services. The competitive relationship between the STS and future ELVs is only part of that equation.

We look forward to working with you and the staff and to assisting the Department and the Advisory Committee in the further development of policy recommendations in this important area.

Sincerely,

Ronald F. Stowe

Ronald F. Stowe
Vice President
Government & Commercial Affairs

lmb
cc: Jennifer L. Dorn
Gerald J. Mossinghoff

Mr. **Nelson**. And I thank you, Mr. Lyons.

Mr. Charles Ordahl, McDonnell Douglas Astronautics. Mr. Ordahl.

STATEMENT OF CHARLES A. ORDAHL, VICE PRESIDENT, SPACE PROGRAMS, McDONNELL DOUGLAS ASTRONAUTICS CO.

Mr. **Ordahl**. I would first of all like to congratulate you, Mr. Nelson, on your election to the chairmanship of the Space Science and Applications Subcommittee. Your dedication to the space program is certainly acknowledged by all and we look forward to working with you.

Mr. **Nelson**. Thank you, sir.

Mr. **Ordahl**. I also want to say that we look forward to working with all the returning members of the subcommittee and with all of you who are new to the subcommittee, we at McDonnell Douglas stand ready to work with you on space related matters at any time.

My complete statement has been submitted for the record and I will summarize.

Mr. Chairman and members of the subcommittee, I would like to thank you for this opportunity to represent McDonnell Douglas in presenting our views on the important subject of shuttle pricing.

Over the last decade McDonnell has made several space commercialization investment decisions, in which space transportation costs and launch vehicle competitive factors were significant considerations.

First, as the Delta ELV prime contractor, McDonnell Douglas commercially upgraded the Delta in the mid-1970's to a company-funded edition of larger first-aid solid motors. Later in the 1980's we considered the possibilities for full commercialization of Delta after the NASA program phase out. We decided not to proceed on that course ourselves, due to uncertainties in the size and the makeup of the marketplace and the unpredictable pricing policies of the European Ariane vehicle.

In two other cases we decided to make major commercial financial commitments based upon the shuttle used at favorable competitive prices and both of these programs are significantly affected by changes in shuttle prices.

One is the EOS project for space manufacturing of pharmaceuticals, which you will hear about later from Mr. Rose, the other is the Payload Assist Module Program [PAM], which I will discuss. The PAM Program was begun in 1976. In the early years it flew as an upper stage on Delta. That part of the program is now complete. We have since concentrated our continuing efforts on the shuttle PAM, called the STS PAM-B, and a growth version called the STS PAM-B-II. PAM-B was first flown on shuttle in 1982 and all remaining launches contracted for are now scheduled on the shuttle.

The overall development and support equipment non recurring investment of these programs is quite large, approximately $155 million. The profitability of this venture is directly tied to the shuttle and the ability of the shuttle and PAM to compete with Ariane. In this regards our experience in 1984 was not very good. The shuttle and PAM lost two repeat mission sales to Ariane because of the lower price quoted by Arianespace. One was the third Australian satellite, the other was the fifth SBS satellite.

These competitions were lost using the current fiscal 1986, 1988 shuttle prices. We see similar situations developing in future years. The viability of the PAM program, the first commercial venture of its kind, is in question. using the 1986, 1988 shuttle rates, let alone future increases.

Should this program falter as a successful profitable venture, which will happen if we cannot achieve additional sales, it will send danger signals to the financial community and other companies who are contemplating commercial space investments.

The shuttle is a major national asset maintained for NASA and DOD missions and it can and should be used to foster and encourage space commercial investments. This can be achieved through a policy of additive cost pricing, in which commercial customers are charged all out-of-pocket added costs incurred in their behalf, but no allocated share of the fixed or capacity cost of the system.

Such pricing will place the shuttle in a position of winning competitions with Ariane and with each win the achievement of the economic benefits of increased shuttle launches and more shuttle related commercial business retained in the United States.

Mr. Chairman, being less competitive in this environment means virtually no competition at all. In our opinion the limited market for new communication satellite launches would be captured in its entirety by Ariane if the shuttle price is increased. In this set of circumstances the shuttle will still remain as a national asset, but will be more expensive to maintain due to the lack of satellite payloads and the withdrawal of potential new space applications.

In summary we believe the shuttle pricing policy is a key element in developing the industrial utilization of space and in maintaining the shuttle as the world's primary satellite launcher. We believe, and recommend, that a competitive shuttle pricing policy, based on additive costs is in the national interest and should be adopted. Thank you very much.

[The prepared statement of Mr. Ordahl follows:]

SPACE SHUTTLE PRICING POLICY

STATEMENT BEFORE THE U.S. HOUSE OF REPRESENTATIVES SUBCOMMITTEE
ON SPACE SCIENCE AND APPLICATIONS
by
Charles A. Crdahl
Vice President - Space Programs
McDonnell Douglas Astronautics Company

Mr. Chairman and members of the Subcommittee, I would like to thank you for this opportunity to represent McDonnell Douglas in presenting our views on the important subject of Shuttle pricing policy from the perspective of an upper stage manufacturer that uses the Space Shuttle.

The McDonnell Douglas Corporation has been involved in the space industry since its earliest days. Although much of the U.S. space program has been government funded, private industry has continued over the years to increase the application of technology derived from NASA research to commercial ventures. The most notable example is satellite communications. We at MDC are proud to have contributed to the success in this area by providing transportation to orbit with the Delta launch vehicle for over two decades and more recently with a family of company funded upper stages for the Space Shuttle.

But, Mr. Chairman, the critical decisions facing us today may determine whether McDonnell Douglas and other commercial firms will be able to continue commercialization of space applications. Increases in the cost of transportation to space by the Shuttle may curtail this emerging industry.

Over the last decade McDonnell Douglas has made several space commercialization investment decisions in which space transportation costs and launch vehicle competitive factors were significant considerations.

First, as the Delta ELV prime contractor, MDAC commercially upgraded Delta in the mid 1970's through a company funded addition of larger first stage solid motors. Later in the early 1980's we considered the possibilities for commercialization of Delta after the NASA program phased out. We decided not to proceed on that course ourselves due to uncertainties in the size and makeup of the market place and the unpredictable pricing policies of the European Ariane vehicle.

In two other cases we decided to make major financial commitments based on STS use at favorable competitive prices and both are significantly effected by changes in Shuttle prices. One is the Electrophoresis Operations in Space project for space manufacturing of pharmaceuticals which you will hear about later from Mr. Jim Rose of MDAC. The other is the Payload Assist Module (PAM) Program which is the primary area that I will discuss here today.

The PAM Program which began in 1976 had two primary goals:

- Provide an upper stage that had the flexibility to fly on both the Delta and Shuttle during the ELV to Shuttle transition era.
- Provide an enduring commercial Shuttle upper stage program after the Delta was phased out by NASA.

The early PAM program fulfilled that goal. Twelve were flown on Delta in the period from 1980 to 1984 and we have now completed all of our contracts for this version. We have concentrated our continuing efforts on the Shuttle PAM called STS/PAM-D, and a growth version, the STS/PAM-DII. The first PAM-D was flown on Shuttle in 1982. As of this date, we have sold 22 STS/PAM-D missions 10 of which have been flown. An additional 35 STS/PAM-DII missions are under contract for launches beginning late this year. Twenty eight are for the Air Force GPS Program and 7 are commercial sector sales. The overall development and support equipment non-recurring investment in these programs is quite large, approximately $155M. The profitability of this venture is directly tied to the Shuttle and the ability of the STS/PAM to compete with the Ariane. In this regard the experience in 1984 of STS/PAM-D vs Ariane competition is pertinent.

In 1984, NASA and MDAC bid a STS/PAM-D to launch the third in a series of Australian National Communications Satellites. This launch was to be a follow-on to the two earlier Australian launches from the Shuttle. STS/PAM-D lost the competition to Ariane on price - a price based on the current FY86-88 Shuttle pricing policy ($71M in '82 dollars). Additionally, in early 1984, the competition to launch the fifth in a series of Satellite Business Systems satellites was lost to Ariane. These contracts were already placed with NASA and MDAC but were cancelled, due to Ariane offers at a lower price.

These two competitions set the tone for what we expect to see in the next several years. In fact the viability of the PAM Program, the first commercial venture of its kind, is in question using the FY86-88 STS prices let alone further increases. Should this program falter as a successful profitable venture, which will happen if we cannot achieve additional sales, it will send danger signals to the financial community and other companies who are contemplating commercial space investments.

The Shuttle is a major national asset maintained for NASA and DOD missions and it can and should also be used to foster and encourage space commercial investments. This can be achieved through a policy of additive cost pricing in which commercial customers are charged all out of pocket costs incurred on their behalf but no allocated share of the fixed or capacity costs of the system. This could provide a Shuttle price of less than the current $71M FY86-88 price. Such pricing will place Shuttle in a position of winning competitions with Ariane and with each win achievement of the economic benefit of increased Shuttle launches and more Shuttle related commercial business retained in the United States.

Mr. Chairman, being less competitive in this environment means no competition at all. If I may draw an analogy with our commercial aircraft market, I would like to relate the similarities.

Due to heavy government support in pricing and financing, Airbus Industries has grown rapidly over the past decade. In fact, aerospace exports - the second largest export of the U.S. - has dropped dramatically. For example, the total U.S. share of free world aerospace sales in 1970 was 80%. By 1980 the market share was 61% (Aerospace Daily - January 23, 1985). Who in this room would have expected Pan American, a flagship U.S. airline, to make such a major commitment to a foreign airframe builder?

Mr. Chairman and members of the Subcommittee, I fear we are on the verge of allowing our space dominance to go the way of our aircraft prominence. We must fully understand the implications of increasing Shuttle pricing. In our opinion, the limited market for new communication satellite launches would be captured in its entirety by Ariane if the Shuttle launch price level is increased. Before we abrogate this area we must fully comprehend the effect of our actions.

If I were asked to outline a scenario on this issue it would be as follows:

- The Shuttle launch price is raised to obtain greater cost recovery and to open the door for commercial expendable launch vehicles.
- The commercial ELV industry is born.
- Ariane, with subsidies, keeps its price below Shuttle and U.S. ELV costs.
- The U.S. ELV market share is not sufficient to provide a return on investment and within a year or two commercial companies abandon their efforts.
- The commercial payloads are committed to Ariane at a lower price than Shuttle.
- The Shuttle is maintained as a national asset and is more expensive to maintain due to lack of satellite payloads and the withdrawal of potential new space applications.

This is not a scenario any of us wants to see.

In summary, McDonnell Douglas Astronautics Company views the Shuttle as a national asset providing unique capabilities that open the door for the emergence of new, billion dollar industrial applications. By helping provide the encouragement to pursue these new technologies, NASA is fulfilling its role on the "cutting-edge" of technology. The Shuttle pricing policy is a key element in developing the industrial utilization of space and in maintaining the Shuttle as the world's primary satellite launcher. We believe and recommend that a competitive Shuttle pricing policy based on additive cost is in the national interest, and should be adopted.

Thank you for inviting me to appear before you today.

Mr. NELSON. Thank you, Mr. Ordahl.

Let's hear from Mr. David Thompson, Orbital Sciences Corp.

STATEMENT OF DAVID W. THOMPSON, CHAIRMAN, PRESIDENT AND CHIEF EXECUTIVE OFFICER, ORBITAL SCIENCES CORP.

Mr. THOMPSON. Mr. Chairman and members of the committee. I appreciate this opportunity to appear before the committee today to present the views of Orbital Sciences Corp. concerning the price of the NASA space shuttle. For reasons that I will describe presently, OSC strongly believes that the country should maintain a stable and low shuttle price.

Mr. Chairman, I request that the full written statement, that I will now summarize, be included in the hearing record. Thank you.

Mr. NELSON. Without objection.

Mr. THOMPSON. To begin, some background information on OSC provides insight into our perspective on the issue of post-1988 space shuttle pricing for commercial and international missions. OSC was formed 3 years ago to finance entirely with private capital the development of low-cost, high-performance upper stage vehicles for use on the space shuttle. The upper stages currently under development are the transfer orbit stage or TOS, the apogee and maneuvering stage or AMS, and a two-stage combination vehicle called TOS/AMS. These upper stages are designed to be launched from the space shuttle to transport their satellite payloads from low Earth orbit, where they are deployed by the shuttle, to higher orbits the shuttle is not designed to reach, such as geosynchronous orbit, or on to planetary trajectories. OSC's vehicles are generally not compatible with existing U.S. commercial expendable launch vehicles.

OSC has invested more funds from private capital markets than any other company in the history of space transportation or, for that matter, in any commercial space venture apart from satellite communications. For example, OSC currently manages the largest research and development limited partnership ever completed in the aerospace industry. This partnership, which raised $50 million dollars from over 900 individual investors, was completed last year by Shearson Lehman Brothers and Rothschild, and with other equity and debt investments makes OSC the most strongly capitalized new space company in the country.

Our company's future is clearly dependent on a frequently operating and reasonably priced shuttle. Our individual and institutional investors, who have backed OSC's shuttle-dependent business with more private capital than has been invested in the entire domestic ELV industry, now anxiously await a decision on shuttle pricing after 1988. Our company and its investors, true pioneers in space commercialization, now face the new risk of drastically higher shuttle prices, which was not present when we embarked on our venture 3 years ago.

Moreover, space shuttle pricing will affect not only the prospects of OSC, but of all other shuttle-dependent commercial industries—such as space materials and biologicals processing. Hence, in turning now to OSC's views on shuttle pricing policy, I believe I speak not only for OSC and its investors, but for the majority of the investment community and for numerous other space companies and entrepreneurs that depend on affordable access to the shuttle for their success.

There are four general arguments why I believe that shuttle prices after 1988 should remain low. First NASA, which decided to abandon older technology ELV's like Delta and Atlas in favor of the space shuttle, has through its development of the shuttle confirmed our country's technological lead in space launch services. This technological lead depends, in many respects, on the accumulation of flight, operations, and maintenance experience with manned, reusable launch systems, such as the shuttle provides. It would indeed be shortsighted if our country walked away from the leading edge of space technology, we have spent the past 15 years, and some $18 billion, working to achieve.

My second major argument is that the space shuttle is more economically efficient than U.S. expendable vehicles. Proponents of ELV's argue that expendable rocket launches are cheaper than those provided by NASA's shuttle if full operating costs for both are compared. However, the facts indicate that even at today's relatively low shuttle flight rate, ELV's do not have an absolute cost advantage. My written statement, to which I refer you for details, contains data supporting this conclusion comparing the Atlas/Centaur to the shuttle.

One corollary argument for a higher shuttle price that I have heard is that the Government should not subsidize, even on a transitional basis, any transportation system which is used by profit-making enterprises. Apart from the fact that NASA's proposed post 1988 shuttle price, which OSC supports, of $87 million, will actually provide the Government with a small profit and thus lower the cost for U.S. taxpayers of operating the shuttle, this argument fails to note the many historical precedents for Government assistance in opening new frontiers, such as our transcontinental railroad or civilian airport and air traffic control system.

In addition, private ELV's themselves would require subsidy because their manufacturers cannot afford to pay full value for the extensive Government equipment and facilities which are necessary for their operations and launch. When the alternative to one subsidy is another subsidy, we should subsidize the future rather than the past.

My third point is that the economic activity in the commercial space industry over the next 10 to 15 years depends on the space shuttle and its unique capabilities far more than on extending, for a few extra years, the life of existing U.S. expendable vehicles. Areas of enormous promise in advanced communications, materials processing, remote sensing, and orbital transportation depend on the reusable, manned shuttle for realization. These endeavors cannot be served, in most cases, by expendable rockets. Hence, the expansion of future commercial activity in space depends on the unique attributes of the shuttle and the current private capital at risk reflects this fact.

Private investors, both individuals and institutions, have placed over 10 times as much capital into commercial space projects dependent on the shuttle as has been invested in U.S. expendable launch vehicle projects. In the initial phase of commercial space ventures, the private capital markets have voted unambiguously for shuttle-based projects. Thus, while ELV proponents argue that a higher shuttle price will promote the commercial development of space by establishing their private ELV's as an early success, it is instead evident that the real prospects for space commercialization rest with the shuttle.

My final argument is based on the fact that the space shuttle provides clear and practical relief to current problems in the balance of trade that domestic ELV's do not. Removing commercial satellites from the shuttle is unlikely to have a positive effect on the market share of U.S. ELV's. The Ariane rocket, developed by a government-subsidized European consortium, consistently priced in recent years to defeat the shuttle, would continue to be priced to defeat private domestic ELV's as well. Ariane has key technological and operational advantages that will enable it to continue to enjoy lower operating costs than older technology U.S. expendable vehicles. No serious effort is being conducted by ELV companies in this country to develop state-of-the-art vehicles which can compete effectively with Ariane. Furthermore, the supply of launch services from shuttle, Ariane and U.S. ELV's is probably going to exceed demand for the foreseeable future. Therefore, raising the shuttle price to help U.S. ELV's is unlikely to have its intended effect.

Further, each payload lost to a foreign launcher means a loss to the U.S. economy of $35 to $70 million or more, a total of up to $1 billion a year by the late 1980's. If other spacecraft technology or service markets follow a shift to foreign launch systems, the revenue lost per mission to the U.S. economy could be two or three times as much. The policy for shuttle pricing after 1988 should reflect this reality of the international space launch service market.

To conclude, a higher shuttle price would be a devastating blow to the pioneering commercial space enterprises that have literally bet their companies on the shuttle. A higher price also is likely to have the effect of forcing commercial and international payloads off the shuttle and onto foreign expendable vehicles. The space shuttle was never intended to be used solely for U.S. Government missions and it would be a national tragedy if forthcoming pricing decisions had the effect of so limiting its use. It is vital to our country's welfare, and certainly to our space future, that its new price preserve use of the space shuttle for commercial and international missions.

Mr. Chairman, this concludes my summary. Thank you.

[The prepared statement of Mr. Thompson follows:]

Statement of

David W. Thompson
Chairman, President and Chief Executive Officer
Orbital Sciences Corporation

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

21 February 1985

Mr. Chairman and Members of the Committee:

I appreciate this opportunity to appear before this Committee to present the views of Orbital Sciences Corporation (OSC) regarding the price of the National Aeronautics and Space Administration's (NASA's) Space Transportation System (or Space Shuttle). For reasons that I will describe later, OSC strongly believes that the country should maintain a stable and low Shuttle price.

I. Introduction

OSC was formed nearly three years ago to finance with private capital the development of low-cost, high-capacity upper stages for use on the Space Shuttle. The upper stages currently under development are the Transfer Orbit Stage (TOS^{TM}), the Apogee and Maneuvering Stage (AMS^{TM}) and the two-stage TOS/AMS^{TM}. These upper stages are designed to be launched from the orbiting Shuttle to transport their satellite payloads from low Earth orbit of the Shuttle (approximately 160 miles above the Earth's surface) to higher orbits that the Shuttle cannot reach, such as geosynchronous orbit (approximately 22,300 miles above the Earth) or planetary trajectories.

The impetus for the commercial development of the TOS, AMS and TOS/AMS was the need for the Shuttle to have cost-effective, medium capacity upper stages that could enable the Shuttle to compete effectively with the French Ariane IV and V expendable launch vehicles (ELVs). Before the advent of OSC's vehicles, no upper stage system could competitively launch communications satellites and other spacecraft of the AMS, TOS or TOS/AMS class. A sophisticated two-stage rocket, the Inertial Upper Stage (IUS), developed by the Air Force primarily for military use on the Shuttle, is expensive and has a lower payload capability than the TOS/AMS. The PAM-D, a currently-available Shuttle upper stage smaller than the AMS, can be used only for payloads weighing less than 3,000 lbs., and the Centaur G and G', the largest upper stages being developed for the Shuttle inventory, can be used economically only for payloads weighing 10,000 lbs. or more.

Recognizing the need for upper stages to fill the Shuttle "competitive gap," NASA and OSC signed a series of cooperative agreements on 17 December 1982, 18 April 1983 and 20 January 1984 providing that OSC would commercially develop the TOS, AMS and TOS/AMS using private funds and at no charge to NASA. In particular, under the terms of the 18 April 1983 agreement, NASA agreed to provide technical monitoring of the TOS development and further agreed not to develop a competing upper stage. OSC contracted with Martin Marietta Corporation for detail design and production of its upper stage vehicles. The TOS development program is approaching Critical Design Review in March, the last major milestone before fabrication and testing, while full-scale AMS and TOS/AMS development contracts with Martin Marietta were initiated in December 1984.

OSC has invested more funds from private capital markets than any other company in the history of space transportation. For example, OSC manages the largest research and development limited partnership ever offered in the aerospace industry, Orbital Research Partners, L.P., which funds the development of TOS and of TOS-related technology in the AMS and TOS/AMS. This partnership, which raised $50 million from over 900 individual investors, was completed last year by Shearson Lehman Brothers and Rothschild Inc., and with other equity and debt investments makes OSC the most strongly capitalized new space company in the country.

This background information provides some insight into OSC's perspective on the issue of post-1988 Space Shuttle pricing for commercial and international missions. Our future is clearly tied to the Shuttle and its price. Our private and institutional investors, who have backed OSC's Shuttle-dependent business with more private capital than has been invested in the entire domestic ELV industry, anxiously await the final policy on Shuttle pricing. This policy will affect not only the prospects of OSC, but of all other Shuttle-dependent commercial industries -- such as space materials and biologicals processing. Hence, in turning now to OSC's views on Shuttle pricing policy, I believe that I speak not only for OSC and its investors, but for the majority of the investment community and for numerous other space companies and entrepreneurs that depend on affordable access to the Shuttle for their success.

II. The U.S. Technological Lead Must be Maintained

There are four general arguments why I believe that Shuttle prices after 1988 should remain low. First, NASA, which decided to abandon older-technology ELVs like Delta and Atlas in favor of the Shuttle, has through its development of the Shuttle confirmed our country's technological lead in space launch services. The Shuttle uses space technology ten to fifteen years more advanced than that of domestic ELVs. Currently available U.S. ELVs were developed largely in the 1950's and 1960's and their continued production offers little prospect of technological or economic advancement. In contrast, the advancement of knowledge and the cumulative increase of technological experience derived from each Shuttle flight is progressing rapidly. Our technological lead in space technology depends in many respects on the accumulation of flight, operations, and maintenance experience with manned, reusable launch systems.

This U.S. lead is not guaranteed, however: the French, Japanese, and British all propose to build reusable launch vehicles. The Soviets apparently have already made several test flights of their own prototype. A Federal policy, such as a drastic increase in Shuttle prices, that fails to maximize the Shuttle flight rate also will fail to maximize the U.S. advantage in a broad range of space launch service technologies. Our country cannot justify walking away from a vanguard of space technology that took fifteen years and $18 billion to create.

III. The Shuttle is More Cost-Efficient Than U.S. ELVs

My second major argument is that the Shuttle is more economically efficient than U.S. ELVs. Proponents of ELVs argue that expendable rocket launches are cheaper than those provided by NASA's Shuttle if full operating costs for both are compared. However, the facts indicate that, even at today's relatively low Shuttle flight rate, ELVs do not have a cost advantage. The manufacturer of the Atlas/Centaur, which has less than 30% of the payload boost capacity to transfer orbit of the Shuttle, recently bid the vehicle at a $65 million break-even price (all dollar amounts are in 1984$). On an equivalent boost basis, the Shuttle (at its current launch cost of $176 million, or $53 million for 30% of its capacity plus $10 million for an appropriate upper stage) is today somewhat less expensive to operate than this ELV.

Because a large portion of the Shuttle's costs are fixed, its operational costs are particularly sensitive to utilization rate. The Shuttle's flight rate should double by 1988, essentially halving the per-mission allocation of its fixed costs. Moreover, with only 15 flights completed out of some 225 planned for the Shuttle over the next ten years, significant learning efficiencies are yet to be realized.

For these reasons, when the Shuttle becomes fully operational, its average launch cost should drop to less than $72 million. It is clear that current domestic ELVs will then be unable to compete with it on a cost basis. Delta, Atlas, and Titan each have flown over 100 times and, consequently, have negligible expected learning curve economies as compared with those for Shuttle, Ariane, or other new foreign entrants in the launch market, such as the forthcoming Japanese H-2 vehicle.

One argument for a higher Shuttle price that I have heard is that the government should not subsidize, even on a transitional basis, any transportation system which is used by profit-making enterprises. Apart from the fact that NASA's proposed post-1988 Shuttle price of $96 million ($87 million in 1982$) for a dedicated launch will actually provide the government with a small "profit" (thus lowering the cost for U.S. taxpayers), this argument fails to note the many precedents for government assistance in opening new frontiers, such as our transcontinental railroad or civilian airport and air traffic control system. In addition, private ELVs themselves would require subsidies, because their manufacturers cannot afford to pay full value for the extensive government equipment and facilities necessary for launch. When the alternative to one subsidy is another subsidy, we should subsidize the future rather than the past.

IV. Industrial Growth and Job Creation in Commercial Space Ventures Depend on the Shuttle

My third point is that industrial growth and job creation in the commercial space industry over the next ten to fifteen years depend on the Shuttle and its unique capabilities far more than on a few extra years of life for current U.S. ELVs. Areas of enormous commercial promise in advanced communications, materials processing, remote sensing and orbital transportation depend on the reusable, manned Shuttle for realization. These endeavors cannot be served by expendable rockets. Hence, the expansion of future commercial activity in space depends on the unique attributes of the Shuttle, and current private capital at risk reflects this fact. Private investors, both individuals and institutions, have placed over ten times as much capital into the more than thirty commercial space firms dependent on the Shuttle as has been invested in five U.S. ELV projects underway. In the initial phase of commercial space ventures, private capital markets have voted unambiguously for Shuttle-based projects. Thus, while ELV proponents argue that a higher Shuttle price will promote the commercial development of space by establishing private ELVs as an early success, it is instead evident that the real prospects for space commercialization rest with the Shuttle.

In addition, removing commercial satellites from the Shuttle, whether by a higher Shuttle price or by fiat, is unlikely to have a positive effect on the market share of U.S. ELVs. The Ariane rocket developed by a government-subsidized European consortium, consistently priced to defeat the Shuttle, would continue to be priced to defeat private ELVs. Ariane has technological and operational advantages that will enable it to continue to enjoy lower costs than older U.S. expendable vehicles. No serious effort is being conducted by ELV companies to develop state-of-the-art vehicles which can compete effectively with Ariane. Consequently, raising the Shuttle price to help U.S. ELVs is unlikely to have its intended effect.

V. The Shuttle Provides Relief to Our Balance of Trade Problem

My final argument is based on the fact that the Shuttle provides clear and practical relief to current problems in the balance of trade that domestic ELVs do not. If a dramatically higher Shuttle price were announced this year, then intensified foreign competition would be created by encouraging new launch service operators (Japanese, Soviets and others) to enter the market and by encouraging Arianespace to expand its capacity. Because of state subsidization and production and operational advantages, these foreign launchers, especially Ariane, would prevail over U.S. ELVs in such a market environment. Each payload lost to a foreign launcher means a loss to the U.S.

economy of $35-70 million or more -- a total of up to $1 billion a year by the late 1980's. If other technology or service markets follow a shift to foreign launch systems, the revenue lost per mission to the U.S. economy could be two or three times as much. At a time when the U.S. must be more determined to meet foreign competition than ever before, and particularly so in the innovative, advanced space technology and services of the next decade and beyond, the policy for Shuttle pricing should reflect the reality of the international market.

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To conclude, a higher Shuttle price is likely to have the effect of forcing commercial and international payloads off the Shuttle and on to foreign ELVs. The Space Shuttle was never intended to be used solely for U.S. government missions, however, and it would be a national tragedy if forthcoming decisions had the effect of so limiting its use. It is vital to our country's welfare that its new price preserve use of the Space Shuttle for commercial and international missions.

DAVID W. THOMPSON

David W. Thompson is Chairman of the Board, President and Chief Executive Officer of Orbital Sciences Corporation (OSC), a project management, marketing, and financial company formed in early 1982 to provide low-cost space transportation to commercial and government customers. Working with Martin Marietta, United Technologies, Rockwell International and Honeywell, its industry partners, and with NASA in cooperative agreements, OSC is developing a new generation of upper stage systems for use on the Space Shuttle.

Before co-founding OSC, Mr. Thompson was Special Assistant to the President of Hughes Aircraft Company's Missile Systems Group, where he was involved in the development of advanced tactical missiles. Previously, he worked as a NASA project manager and engineer on the Shuttle's propulsion systems at Marshall Space Flight Center and on the Viking/Mars landing mission at the Jet Propulsion Laboratory. Mr. Thompson also participated in the design of the Shuttle autopilot at Draper Laboratory and has been affiliated with TRW Systems Group and Rand Corporation on several advanced space projects.

He has received awards from NASA, the American Institute of Aeronautics and Astronautics, and the Space Foundation for his roles in the Space Shuttle and Viking programs and his work in space commercialization.

Mr. Thompson received an M.B.A. from Harvard Business School, where he was a Rockwell International Fellow, an M.S. in Aeronautics from California Institute of Technology, where he held Hertz Foundation, National Science Foundation and Guggenheim Jet Propulsion Fellowships, and a B.S. in Aeronautics and Astronautics from Massachusetts Institute of Technology, where he was the National Space Club's Goddard Scholar, a National Merit Scholar and the recipient of the DeFlorez Prize for Aerospace Engineering.

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Mr. NELSON. Thank you, appreciate it, Mr. Thompson.

Dr. Townsend from Fairchild.

STATEMENT OF DR. JOHN W. TOWNSEND, JR., PRESIDENT, FAIRCHILD SPACE CO.

Dr. TOWNSEND. Mr. Chairman, thank you for the opportunity to appear before you this afternoon to present my views on a subject that is of considerable interest to me personally and to my company. I will keep my remarks brief to allow plenty of time for questions.

The issue we face today is a classic case of competing interests with diametrically opposite views, each with a worthwhile purpose and each that can be said to be in the national interest. On the one hand, we have a number of potentially viable commercial activities in space that will need and, in fact, must use the space shuttle. On the other hand, an activity that properly views the shuttle as a competitor. The first of course are materials processing, upper stages for commercial satellite launchings, and sortie and long-term free flying satellite experimentation; the other expendable launch vehicles. The issue is how shuttle launch services should be priced. Those of us that need the shuttle want low prices, the ELV people want high prices.

I cannot sit here today and tell you that one view is right and the other wrong, but I can make some observations. My company needs lower prices to insure success with our Leasecraft Program. We can probably tolerate a very small increase in shuttle prices, since our satellite is launched only once and stays in orbit indefinitely after that, but we must have customers who lease on-orbit services from us and some of them plan frequent flights to our satellites. By frequent, I mean at intervals of as few as 6 months in one case and every 18 months or so in another case. We may also have to visit our satellite for maintenance repair or replenishment, as necessary. My view is that prices are already too high and any significant increase will probably eliminate some ventures, considering the fact that most of us face considerable risk as things stand now. I do not know what the ELV people really want, but I have heard comments to the effect that shuttle prices should be increased a factor of two. This kind of increase might or might not result in eliminating any shuttle launch service subsidies, depending upon the number of launches one assumes each year, but it would certainly put a number of us that need the shuttle out of business for the foreseeable future.

What to do about the dilemma? My personal belief is that the real competition that the ELV interests face is the French Ariane. If shuttle prices go way up I believe Ariane will move in very quickly to capture most of the market for the launching of commercial communications satellites. However, if this view is wrong and a policy decision is made to help the ELV interest or to bring the shuttle into breakeven with modest launch rates, then I see the only alternative to be two tier pricing if we are to encourage bringing into existence the kinds of space commercialization activity that depend on the shuttle and ultimately the space station. Under this scheme the lowest pricing tier would be the marginal costs of flying new commercial ventures in space.

Mr. Chairman, I would like to close with a final thought that might bear scrutinizing. I wonder if we, as a nation, are doing the right thing to put heavy pressure on NASA to make the shuttle pay off. These four shuttles are a very precious asset. They must last for a whole decade. Even if we proceed apace, which is not likely, a new replacement shuttle system could not be operational before the mid-1990's. Without a high level of flight activity from the present fleet, and perhaps even a fifth Orbiter, there will be no space station. Pressing for two dozen flights per year may just not be in the national interest. The vehicle will wear out more quickly and the exposure to an accident will increase. Further, even if we continue to force NASA to break even, Jim Beggs may now be in a position of a man trying to hold water in his hand, but watching it run out between his fingers. Ariane has already made inroads on his commercial comsat launchings. The Air Force is proceeding with a heavy ELV from the cape. Just recently I've read that they also plan to use Titan-2's taken from silos for polar launches from Vandenberg. The payloads would be the Defense Meteorological Satellite Program and NOAA's similar meteorological satellites. In addition, raising shuttle prices significantly at this time will drive additional commercial comsat customers away and further erode NASA's market.

An alternative then might well be to not use the space shuttle at all to launch commercial communications satellites. Instead, save it for the launch of NASA research and development satellites, DOD missions that need it, onboard scientific and applications research, the space station, when ready, and those beginning ventures in space commercialization that require it. I recognize that this suggestion will not be popular with the executive branch, up here on the Hill, and with others trying legitimately to keep the Federal budget down. I also realize that my friends, who hope to develop new upper stages for the shuttle are left out, but perhaps they can find profit in developing new hardware for expendable launch vehicles. In any event, our country's best interest may require an approach of this sort if we are to realize a maximum benefit from our major investment in the shuttle.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Townsend follows:]

Shuttle Pricing Testimony
by Dr. John W. Townsend, Jr., President
Fairchild Space Company
Before the Subcommittee on Space Science and Applications
February 21, 1985

Mr. Chairman, thank you for the opportunity to appear before you this afternoon to present my views on a subject that is of considerable interest to me personally and to my company. I will keep my remarks brief to allow plenty of time for questions.

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What to do about the dilema? My personal belief is that the real competition that the ELV interests face is the French Ariane. If Shuttle prices go way up, I believe Ariane will move in very quickly to capture most of the market for the launching of commercial communications satellites. However, if this view is wrong and a policy decision is made to help the ELV interests or to bring the Shuttle into breakeven with modest launch rates, then I see the only alternative to be two tier pricing if we are to encourage bringing into existence the kinds of space commercialization activity that depend on the Shuttle and ultimately the Space Station. Under this scheme the lowest pricing tier would be the marginal costs of flying new commercial ventures into space.

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Thank you, Mr. Chairman.

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Mr. **Nelson**. Thank you, Dr. Townsend.
Mr. Rose, McDonnell Douglas.

STATEMENT OF JAMES T. ROSE, DIRECTOR, ELECTROPHORESIS OPERATIONS IN SPACE, McDONNELL DOUGLAS ASTRONAUTICS CO.

Mr. **Rose**. I am pleased to appear before you as a representative from a private company, which has been working for 8 years to manufacture commercial products in space.

In 1977, anticipating the success of the space shuttle, the McDonnell Douglas Corp., with its own funds, began working on a project that could lead to dramatic breakthroughs in the treatment of a number of diseases like diabetes, emphysema, dwarfism, thrombosis, and viral infection. At the heart of this project, called electrophoresis operations in space, or EOS, is a device which obtains certain proteins and cells by separating them from other biological materials.

The National Aeronautics and Space Administration is furnishing flight time for experimental operations of the EOS device as part of the joint endeavor policy to encourage private investment in space industrialization.

The device has flown on five shuttle flights to test its operational characteristics and to verify the advantages of processing in space. The results from these tests are dramatic. In the weightless environment of space, the device separated over 700 times more material than it can on Earth and it achieved purity levels more than four times greater.

We are aggressively continuing our program with two mid-deck flights this year, in March and August, and we will be introducing our EOS production system in November. This system will increase our capacity 24 times and will eventually produce material for our first commercial sales, which are expected to begin in 1988. McDonnell Douglas has been, and is, very serious about this endeavor. It is already a multimillion-dollar investment.

The key to our program, and material processing programs to follow, is the space shuttle. The shuttle gives us a safe, routine way to retrieve what we send into space. The shuttle's success has opened a new frontier for economic expansion and industrial growth. New directions, new technologies, new and improved products. This is what true space commercialization is about. The role of the space shuttle cannot be over-emphasized.

Shuttle pricing policy will have a decisive impact on the number of companies which will participate, the number of technologies which will be explored, the number of products which will be developed.

Our own experience may illuminate the danger posed to the commercialization of space by ever-increasing shuttle prices.

Like most commercial companies, McDonnell Douglas requires that new investment opportunities meet certain return-on-investment criteria. Potential internal rate of returns on investment, risk adjusted rate of returns on investment, pretax earnings to sales potential and other parameters are used as indicators which decide the fate of a new product or technology. EOS has undergone such scrutiny.

When we examine the relationship of shuttle transportation costs to new biological products for development, certain trends appear. Biological material considered marginal as new development products show shuttle transportation costs averaging between 22 percent and 25 percent of the expected selling price. Materials with excellent promise for development show shuttle transportation costs contributing approximately 12 percent to the expected selling price.

When selecting our first product for development in 1980, the price for a dedicated shuttle flight was $31 million in constant 1982 dollars. This contributed 11 percent to our sales forecast. The new shuttle rate of $71 million announced in 1982 increased transportation costs from 11 percent to 25 percent. This jump makes our product only marginally acceptable.

However, since we had learned a few things about our process and product, we were able to improve the production performance and limit transportation cost growth to only 14 percent.

Mr. Chairman and members of the committee, a shuttle price increase to $87 million would be pushing our transportation cost back into the 20 percent range, and this time I have no aces to play.

I should note here that when the shuttle price increased from $31 million to $71 million, we were able to use our experience to avoid the profit-eating lion. If not for that experience we would have backed away from the program or looked for a new product. We have studied 12 highly attractive natural biological products for their therapeutic value to the population at large. At the original shuttle price of $31 million, 11 of these products were viable for development. Today only six meet the test for economic viability, and, at the proposed rate of $87 million, only four would survive.

When we started this space commercialization program 8 years ago, we believed there was the potential for our future business to be multiproduct oriented with plenty of opportunities for expansion and growth. Today we are facing very limited growth. And, the number of possible products has been trimmed to perhaps just one.

Our data indicate that there will be many useful biological drugs whose market economics will not support the increase in the cost of space transportation. Many could be called "orphan drugs," products that are needed, but no one wants to make.

To herald commercialization of space as a major national objective while increasing the costs of the necessary transportation system is a tragic contradiction. To discourage use of the space shuttle in the name of supporting the privitization of some very old, expendable technology is not promoting space commercialization. It is succumbing to the expedient. It threatens to choke off a historic movement in American business before it has time to blossom.

Already, the legal community is discussing space commercialization, nonaerospace companies are showing interest in the space environment for research and product development, in the financial communities, both the staid investment concerns and the venture capital houses are looking to space business with high hopes. Even now a consortium arrangement between McDonnell Douglas and a number of non-competitive, non-aerospace companies is being developed. This could substantially increase participation by the private sector in space related processes and product development through sharing the research and development expenditures and potential applications.

In short, the enthusiasm of these newcomers is growing. This is not the time to chase them off with exorbitant price increases. Indeed, we should be thinking about a roll back in shuttle prices to capture these attracted, yet anxious potential customers.

Mr. Chairman and members of the committee, we stand at the threshold of a bright, exciting future, a future free from many of the diseases which plagued previous generations, a future filled with "wonder" products and "super" materials that our imaginations can't even dream of, a future fueled by a new space-borne industrial revolution. Affordable, retrievable space transportation is absolutely essential if we are to make this future our world. Our current program, and those to follow, must have the space shuttle. We have no other alternative, and so I urge you, in the strongest terms, give us the tools to lead the Nation towards this world of enterprise and hope. You can lay the foundation for our next industrial base. For its promise, the future looks to you.

Thank you.

[The prepared statement of Mr. Rose follows:]

SPACE SHUTTLE PRICING POLICY

STATEMENT BEFORE THE U.S. HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
by
James T. Rose
Director, Electrophoresis Operations in Space
McDonnell Douglas Astronautics Company
February 21, 1985

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Mr. Chairman and Members of the Committee, we stand at the threshold of a bright, exciting future--a future free from many of the diseases which plagued previous generations, a future filled with "wonder" products and "super" materials that our imaginations can't even dream of, a future fueled by a new, space-borne industrial revolution. Affordable, retrievable space transportation is absolutely essential if we are to make this future our world. Our current program, and those to follow, must have the space shuttle---we have no alternative.

And so, I urge you, in the strongest terms, give us the tools to lead the nation toward this world of enterprise and hope. You can lay the foundation for our next industrial base. For its promise, the future looks to you.

Thank you.

Mr. NELSON. And I want to thank you all. I want to thank the members of both panels for excellent presentations, the ELV panel, as well as the present panel, the user panel. You've made excellent statements, very clear and we are the beneficiaries of your testimony. And understanding various people's point of view on shuttle pricing, which is a very highly technical sort of ethereal kind of a subject and yet, it has extremely important implications throughout the American aerospace.

Now, before I get into some questions, let me ask you, Mr. Rose, on another subject, and I just have not been briefed on this. What can you tell me about the potential contamination that took place on the electrophoresis residue after the shuttle landed last time? Or when the last time you flew electrophoresis?

Mr. ROSE. We—when we retrieved the material we found a high level of endotoxin. The endotoxins are the debris left from bacterial growth. Bacteria grows when your system is not kept in a highly sterile state. What we—what happened to us, we operated the equipment at much higher temperatures than we'd simulated in our sim-flight missions. It's a fairly straight forward problem. There's no major difficulty and we know what it was and we're going to—it's going to be corrected, in fact we're going to verify that in March, on the next flight.

Mr. NELSON. Did it render your experiment then useless?

Mr. ROSE. No, well the experiment has many facets to it. The engineering aspects of the experiment of checking some of the production methods was very successful. The materials were separated and Charlie Walker was able to do in-flight essays, which is a first, biological essays, which verified the materials were separating properly and being collected properly. The materials, when we brought them back because of the endotoxin problem, were rendered useless to be used in actual animal testing by Ortho Pharmaceuticals, that's the only part of the flight that wasn't positive.

Mr. NELSON. Can you make up time that you lost there?

Mr. ROSE. Yes, we could make that time up other than that one of our key driving issues in the program right now is—has nothing to do with space or electrophoresis, is that we are learning like the biotechnology companies a view, how to develop large scale quantities of material to take into space to separate. So, that is our pacing item right now. We believe we will have that well under control by early spring.

Mr. NELSON. OK, thank you for that update, I appreciate it.

OK, let me get from each of you, what's the total amount of money that each of your firms has invested in the space commercialization ventures? Let's just go right down the list.

Dr. Roney.

Dr. RONEY. Well, I wouldn't be able to give you a total figure for everything we've invested in the space and satellite business, but I'd have to tell you it measures in the hundreds of millions of dollars.

Mr. NELSON. Mr. Lyons.

Mr. LYONS. We're in the approximately $7 billion investment range at the present time, at SBS.

Mr. NELSON. Mr. Ordahl?

Mr. ORDAHL. On our PAM Program, including the development and the provisioning of the airborne support equipment that goes on each shuttle flight, about $155 million and then if we count the earlier upgrade of the Delta and the Caster-4 motors, probably another 10, so $165 million.

Mr. NELSON. Mr. Thompson.

Mr. THOMPSON. To date, $64 million from venture capital, investment banking, debt and limited partnership sources. We are spending that money now at the rate of somewhat more than $2.5 million a month in product development programs. We will be in the financial markets later this year for an additional investment of $30 to $35 million.

Dr. TOWNSEND. In our Leasecraft Program we're already spent slightly over $7 million.

Mr. NELSON. Mr. Rose?

Mr. ROSE. One of the—there are only two things that for 8 years we've been about to maintain secrecy on in the electrophoresis program, that's what the first product is and how much money we've spending. We don't divulge that number, but it is in the multi-millions of dollars and much higher than any figure I heard from the first panel.

Mr. NELSON. All right now. From your perspective what is the relative size of the potential launch services market compared to all other segments of the commercial space market? Do you understand what I'm saying? You all are involved in space commercial activities. I'm going to ask you a comparison, if you can give it to me in a percentage of now, which would be, let's say, this decade, and then let's look at the turn of the century, the year 2000. We're going to measure the commercial launch services market compared to the overall commercialization in space.

Anybody want to take that.

Mr. ROSE. I will only make a—if we look at some of the statistics that we've come up with, the transportation from the point of view of the materials processing program, should run between 10 and 20 percent of the projected sales of products, so if you've got a billion dollar annual market in sales you can get a feel for what transportation should be commercially. It doesn't mean that it will be that, but I think that is a rule of thumb. We can foresee in space, you know, there are many—there are many market projections going around about what it will be by the year 2000, by the year 2020, but I would say a rule of thumb is you're not going to have those types of commercial programs if the costs of transportation are much higher than that.

Mr. NELSON. Mr. Thompson?

Mr. THOMPSON. Mr. Chairman, our analysis indicates that today, transportation-related activities represent slightly less than 50 percent of all commercial activities in space. If we look out 15 years, to the year 2000, under the kind of optimistic scenarios that we hope become fact, we would see that percentage declining to something like 20 to 25 percent.

Mr. NELSON. Anybody else with any different feeling?

Dr. TOWNSEND. I was going to guess about 30 percent. We've done—taken some looks at things of that nature.

Dr. RONEY. Yes, I'd say for the commercial satellite, communication satellite business, our estimate runs that the transportation cost accounts for about half the total cost of putting a satellite in orbit. As far as a commercial satellite, commercial communications satellite system is concerned there is a lot of other costs besides just the satellite in orbit, but the cost of the satellite, the spacecrafts themselves, and the transportation, are comparable.

Mr. NELSON. OK, Mr. Lyons, on page 5 of your testimony you said, "Based upon the above considerations it is our strong recommendation that the STS price be established at a level consistent with the recovery of the additive cost of the launch service."

Now, let me understand your definition of additive costs.

Mr. LYONS. Again I'm presuming that there is an STS program dedicated to the national interest, DOD and scientific research and exploration, which entails the maintenance of a body of people at the cape and at Johnson Space Center in order to support that activity, to run the fleet of vehicles, a certain number of missions each years. Those costs, I don't feel, should be borne, by the commercial satellite user community. What I address as the additive costs are those costs specifically associated with a single flight. Those are the costs of the expendable solids associated with that. With the fuel for the Orbiter, with all of the engineering that we have to do with Johnson Space Center and with Kennedy Space Center, to get our mission integrated with the rest of the shuttle mission, all of those costs, I feel, are the appropriate levels.

Mr. NELSON. OK now, let me see if I can put some dollar figures to this. We've heard a lot of dollar figures bandied about. Are you talking about basically in the range of $43 million per payload? Or are you talking about the present pricing policy of $71 or are you talking about greater?

Mr. LYONS. I, quite frankly, Mr. Chairman, I don't have an insight into NASA's accounting procedures and costs procedures. You know, what I'm saying is that we, as a commercial entity, are willing to bear the—our appropriate share of costs, as related to our specific flight. What those costs are, you know, I'm just not in a position to give you any kind of assessment. Yes, I have seen those numbers bandied around.

Mr. NELSON. Mr. Rose, OK, Dr. Townsend.

Dr. TOWNSEND. Yes, I think we're talking about additional, identifiable costs somewhere in the range of $30 to $40 million.

Mr. NELSON. Additive cost?

Dr. TOWNSEND. That's additive costs, that's right.

Mr. NELSON. Alright.

Dr. TOWNSEND. Identifiable costs, costs you can put your finger on. Additional costs added to the total cost of that flight because of integrating your payload and flying it, and the expendables that go with that.

Mr. NELSON. OK, now let me put you all on the spot. Going through all six of you. What do you think should be the Government's pricing policy for the space shuttle, and give me a dollar figure, if you can? Dr. Roney?

Dr. RONEY. I think that our business—the business we represent could sustain an increase in the cost of a few percent, maybe 10 or

15 percent of the current cost, so in the neighborhood of $80 million for a dedicated shuttle is probably what we could sustain.

Mr. **Nelson**. Mr. Lyons.

Mr. **Lyons**. Again, I've indicated the basis. I feel that the costs that we're paying now are acceptable, and some small increase in those costs to reflect the, you know, the future, I believe NASA has proposed a number like $82 million, would still be tolerable from the standpoint of our company.

Mr. **Nelson**. Mr. Ordahl.

Mr. **Ordahl**. From our point of view, as I mentioned in my testimony, that we're currently losing competitions to Ariane at the current price of $71 million. We support the additive cost-pricing policy, which I think would be, maybe, in my estimation, in the range of $50 million. We think that a $50 million price would put us back in a good competitive position with Ariane.

Mr. **Nelson**. Mr. Thompson.

Mr. **Thompson**. From the standpoint of OSC, we would like to see the price for the post-1988 period remain very close to what it currently is, from the end of this year through that time, which in 1982 dollars is around $72 million. However, from the broader perspective of encouraging more than just the first round of commercial ventures that you are hearing representatives speak about today, we would like to see a lower price in the range of $50 to $60 million 1982 dollars.

Mr. **Nelson**. Dr. Townsend?

Dr. **Townsend**. I would go with $50.

Mr. **Nelson**. Mr. Rose.

Mr. **Rose**. I believe in the additive price concept because that is something tangible that you can identify, if it be $30 or $50 million in that range would certainly restore a number of products that we have looked at and examined today and will not be costly—cost effective to develop.

Mr. **Nelson**. OK, I want to ask Mr. Lyons about that because in his testimony you said that the STS price should be established—well, I'll just quote you, "established at a level consistent with the recovery of the additive costs of the launch service," and yet you said $83 billion was your figure?

Mr. **Lyons**. I think that that is the fair and just price for users, such as SBS, to pay. What I was responding to in the second question was, what kind of changes in the price that we have now would be tolerable to a company like SBS, so that they remain competitive in their market, and as Dr. Roney indicated, some growth in price, you know, could be tolerated. But, I don't think that's necessarily fair.

Mr. **Nelson**. So what you're saying is fair is the additive cost, and you said you don't know how to define that, but if Mr. Rose and Dr. Townsend are correct that it's in the range of $30 to $50, that's what you said you think would be fair.

Mr. **Lyons**. That is correct. I think that is the fair price.

Dr. **Townsend**. Mr. Chairman, I think our problem here is that penetrating NASA's accounting on the shuttle is somewhat difficult. You would have to sit them down and say, now this is the price we're interested in. What would it be if you just charged the marginal or additional costs? They have not been doing that, of course; they've been charging more than that.

Mr. NELSON. OK. Mr. Thompson, you had said that each payload lost to a foreign launcher means a loss to the U.S. economy of $35 to $70 million or more. Explain that?

Mr. THOMPSON. Well, that's the lost revenue to various providers in the launch service food chain, which would include for payloads flying on the shuttle revenue to NASA and revenue to upper stage manufacturers, such as McDonnell Douglas and OSC. For a payload launched on a vehicle like the Atlas Centaur, it would represent the lost revenues to the manufacturer of that vehicle. The range reflects that—the difference between the current generation of PAM-B, PAM-B-II payloads that are flying today or shortly will be flying, and the payloads which will be flying several years from now that are larger than that and which are more expensive to launch and represent a larger revenue lost.

Beyond that, however, there is often a multiplier effect in that other parts of providing satellite communications may also move to overseas suppliers. The ground stations, the satellites themselves, and other things that are involved in that multiplier, in our estimate, could be as high as three to one.

Mr. NELSON. That's what I wanted to clarify. You were speaking about $35 to $70 million lost as being actual dollar loss, not putting the multiplier effect on it?

Mr. THOMPSON. That's correct.

Mr. NELSON. OK. All right, Mr. Smith.

Mr. SMITH. Just one quick question, Mr. Chairman. I sense, as I listen to the six of you, that—maybe I'm wrong, that there seems to be—somewhere along the line there was a commitment, formal or informal, understood or implied or whatever, about just what exactly these things would—would cost you. Could some—one or two of you, expound on that a bit, I mean, was a commitment made? If so, who made it? I'd be very interested in that. I think in the free enterprise system we all take risks, and I get the feeling, as I listen to you, that it is something a little bit beyond the normal business risk and I'm interested in hearing your response on that.

Dr. TOWNSEND. I'll take a crack at it. I think the thing that's happened has been that NASA has not had the launch rate that they expected out of the shuttle. In the first place, it slipped a number of years, as you know, and second, there have been some—some difficulties, and that has led to the fact that the present costs are more per launch than they had expected, and, in fact, than OMB had expected, so there has been more pressure on them to reduce the costs even further and to get more flights.

Your fixed costs, you can't do anything about, they're sunk, if you will, so what you can do, of course, is to get more utilization out of—if they can get more utilization out of their vehicle, they can reduce the cost. I don't think any of us were promised anything except that NASA has had a policy of trying to nurture endeavors of a new sort, dating back to NACA days—but I think really the thing that's happened has been the fact that the launch rate hasn't been what everybody anticipated.

Mr. ROSE. Let me add to that, because we actually started discussions with NASA in looking at the economics of developing the technology that we have developed and are trying to now commercialize. We knew at that time the pricing policy was $31 million in 1982 numbers, and this was in 1977. Well, for it to go from $31 million to $71 million by 1982 and with the advent of another price that could go from $87 to $130 million, there's virtually no way that anybody who is investing money today to do research on, can sit back and be content that he has anything viable he can produce with those—he has a very uncomfortable feeling. We need to get stability in the pricing, if for no other reason. Wherever its going to be, let it be, but there is, you know, it's disconcerting to go through these type of price increases that are not inflationary, necessarily. We can handle inflation because we've got to just raise the price to be according to inflation, but I cannot handle just arbitrarily the shuttle is going to jump this much in transportation, which we have been depending on and have to depend on, because we have to bring everything back that we send up there, routinely.

Mr. SMITH. Suppose we raised the prices above the $80 million mark, would that—would that make domestic ELV's viable or not?

Dr. TOWNSEND. I'm not in the ELV business because I don't use ELV's—we cannot use ELV's for our business. There is no possible or practicable way to do that. We would begin to look very seriously, and any form of setback would probably be catastrophic to us, because everytime the shuttle goes up it erodes some of the safety margin that you've got.

Mr. SMITH. Thank you. I'd be interested in somebody else's response on the same——

Mr. ORDAHL. I might comment a little bit on the question about the ELV viability. If you raise the shuttle price, then it becomes a question of the competitiveness between our ELV's and the French ELV. And if the market is large enough maybe each party can get enough of a share to make a worthwhile thing out of the thing. The problem, and it's really the reason that McDonnell Douglas did not commercialize the Delta, quite frankly, is because we have not shared this view that there was a very large expansion in the communication satellite business ahead of us. I was with this committee in 1983 and that same subject came up, and I think the testimony at that time will show that I said that I thought that there might be 10 or 12 Delta-class missions up for competition over a period of time in the future. As I look at it today I think that maybe 10 is on the high side, in the Delta class, in the Delta PAM-D class. So now then you're faced with the situation, well, who's going to win. We all know, at least in my experience, launch rate is a pretty important competitive factor. Whoever can get the launch rate up can get the prices down, and that's pretty significant. And I feel that the French—that the Europeans have developed a vehicle, I think they understand that and they've developed a vehicle that's very uniquely designed for this particular market segment. It's capable of handling small satellites and big satellites. Very flexible. Two launches, single launch crew, get the launch rate up, cost down, win.

Now, can we compete with that? We have a situation where we have a Delta, we have an Atlas/Centaur, we have a Titan. I don't know. I won't answer, I mean I don't know what the end—I can't predict. I just see it as a very, very tough competitive marketplace. Who will win, only the future could tell.

Mr. SMITH. I have one quick question, Mr. Chairman.

Mr. NELSON. Sure.

Mr. SMITH. Correct me if I'm wrong, am I hearing here that either subsidize beyond the $80 million or lose American involvement on the shuttle and give way to foreign competition. Is that the alternative that this committee faces or this country faces?

Mr. ORDAHL. My personal feeling is that the Europeans are fully dedicated to their—to their goal and that if they—if we should raise the shuttle price at this time they are primed to take maximum advantage of that. They will continue, in some way, to subsidize enough to undercut us at a time when emerging, if you will, ELV industry, is just trying to get under way. That's the problem, they've got more staying power, strength, at this time period and so, I think its a very dangerous situation if you really want to protect keeping launches here in the United States for communication satellites.

Mr. NELSON. Let the record show that all of the panel nodded their head "yes" to Mr. Smith's question except Dr. Roney. He had a furrowed brow, let's hear your comment.

Dr. RONEY. I'm not sure I understood the question. He said—do you mean subsidization of the shuttle above $80, is that what you meant? I—my personal opinion is that that doesn't require any subsidization, if we're talking about a marginal cost basis.

Mr. NELSON. He's saying pricing.

Dr. RONEY. What?

Mr. NELSON. You're saying pricing above $80.

Dr. RONEY. OK, I see. I think pricing above $80 will start to erode the communication satellite business. It won't wipe it out, but it will start——

Mr. NELSON. Several of you—go ahead, you have a comment to that, Mr. Lyons?

Mr. LYONS. I just wanted to say that, you know, when we looked at the Transpace offering there really was a chicken and a egg problem. You know, how can I, as an individual user, selecting a launch service, select from somebody, unless he can bring to me four, you know four, five other people in the same timeframe, who also are going to need a launch service and have contracted for it. You know, there almost, in my mind, needs to be some kind of subsidization or stimulation of the ELV's so that they can have a guaranteed launch rate, at some level, in order to actively and, you know, effectively compete with the Arianespace vehicle, which has the brunt of the European and international Intelsat-type payloads to service them.

Mr. NELSON. Well, then do any of you have any further comment on that, which is what we've been talking about, the general area. Some of you who have not commented on the question of a totally privately operated U.S. ELV, can it be competitive with a Government-supported Ariane?

Mr. THOMPSON. Mr. Chairman, if I could move back a step to Mr. Smith's earlier question, which I think has some relation to your question now, and that concerns the commitment or the promise about things that perhaps now seem to not be fulfilled. I think that the evidence before you, with a company of the size and stature of McDonnell Douglas or perhaps at the other end of the size range a company like OSC, together making investments on the scale of a quarter of a billion dollars in shuttle-dependent ventures, in fact quite directly states that we believe that there was a commitment expressed both explicitly and implicitly over a long period of time beginning in the mid-1970's that the space shuttle was going to be exactly what NASA's official name for it calls it, the *National* (emphasis added) Space Transportation System. I don't think either of us would have invested our funds had we—or certainly would have invested our funds with quite a bit more though given to it, if we thought the prospects existed for that position of the shuttle to be undercut and for various catagories of payloads to be taken to other launch systems. So, we think that the investment that the country has made in the shuttle was based on a promise that it was going to be our principal means of getting into and out of space and we might retain certain small-capacity Scout launch vehicles and, for national security purposes, Titan launch vehicles, but that everything in the middle was going to be superceded by the more advanced, and if you fly it often enough and support it strongly enough now, the more economic shuttle. So, we did see some kind of commitment being made before we made our individual investment decisions.

Mr. NELSON. Were there any of you who—and I'm coming to you, Ms. Meyers, following along right to this, were there any of you who did not make a comment in your formal statement as to the importance of your commercial space venture, vis-a-vis the shuttle, space shuttle, that you want to make that statement here. I know some of you did, but I can't remember if all of you made a comment as to whether or not the space shuttle was important to your venture. Everybody feel like you expressed yourself on that?

[Witnesses nodded yes.]

Mr. NELSON. Ms. Meyers?

Ms. MEYERS. I have no questions at this time.

Mr. NELSON. Thank you. All right. Any more, Mr. Smith. OK, you know we're doing so good on time here, do any of you have a closing comment that you would like to make?

Dr. RONEY. I might like to respond partly to the question you just posed. I think perhaps in my statement I did not spell out explicitly enough the dependence of at least some of our business and some of our investments in the shuttle, regardless of price. That's to say in reliance on the stated Government's position that the Shuttle was to be their launch system, we have invested in taking advantage of its physical characteristics in a way that we're now dependent upon it. And so if it suddenly became priced out of the market or followed what Dr. Townsend suggests, and it wasn't offered to communication satellites, it would be very damaging to us.

Mr. NELSON. Any further comments?

Dr. TOWNSEND. Yes, I might make a comment with respect to the last subject. In the first place I don't think any of us can state, categorically that we know what the French are going to do, but I think there are some lessons from simple business economics. Let's assume that the shuttle is priced high, so that in effect there are no more commercial communication satellite launches. Ariane will immediately chase that price up, because they don't like to pay subsidies anymore than we do, but they'll chase it only to the point where their market share is—is at its most optimum point and that is probably where they have about 70 percent of the market in my judgment, something like that. Beyond that, given the average of all the forecasts, they're probably going to have to put in considerably—well, put in new facilities, another launch pad, things of that nature. There will be a point at which the margin begins to hurt you. I would be very surprised if they didn't drive very hard to knock out any competition while it still was in its infancy.

Mr. NELSON. All right, now Dr. Townsend, now having said that, do you have a dollar figure in an equivalent shuttle payload that you can apply to that point at which you cross that marginal threshold?

Dr. TOWNSEND. Well, Fairchild Industries owns half of American Satellite and we have three satellites—three Comsats to launch, one of which is on the—is on the shuttle and is due to be launched this summer. The second one is going to be kept on the ground for the time being and there are parts for a third. We've been debating this. Our initial reaction when we made the decision a number of years back, was essentially a partriotic one. We weren't going to help Ariane if we could avoid it, and so we went with the shuttle, but I can tell you, if that shuttle price goes up—certainly a double would knock us out. There's no question. Now, 10, 20 percent, knowing how my chairman feels about this, we'd probably yell, but we'd swallow it. Above that, I think you've got a serious problem. So——

Mr. LYONS. There's another aspect——

Mr. NELSON. I'm talking about the margin—I know what your reaction is, now the margin at which you're talking about Arianespace would not be able to build for the future. I'm talking about what you—the dollar figure.

Dr. TOWNSEND. Yes, OK, a dollar figure, that's hard. I tend to think in terms of launches because it's the number of launchings that involve, you know, really tell you what kind of investment is required. They're planning for 17 now, I think, aren't they, something around that number. Now probably somewhere around 25 they're going to get in trouble and going to have to put in a good deal of new facility. Well, this has happened to NASA with the shuttle—you know we're going to bring up another pad pretty soon. We've added facilities for the boosters, the external solid rockets, [SRB's] and all down the line we've added new facility to handle the higher launch rates, so that would be a rough guess.

Now, you see, the reason it's hard to give you a dollar number is that you know they are subsidized and if they want, say, 80 percent of the market and they can handle the launches, they'll go for it. I would in the same position.

Mr. NELSON. But, you're thinking 25 launches per year.

Dr. TOWNSEND. Something, that's a——

Mr. NELSON. From the Ariane, by the Ariane.

Dr. TOWNSEND. That's what we call a RAG in this business, ragged ass guess. You can take that out.

Mr. NELSON. Mr. Lyons.

Mr. LYONS. I just wanted——

Mr. **Nelson**. That's close enough for Government work. Yes, sir.

Mr. **Lyons**. I just wanted to reflect on something of an irony, probably seven or eight years ago we were faced with the opportunity to fly on the shuttle instead of these expendable launch vehicles, and I met that challenge with about as much reluctance as I'm expressing today in the other respect. And the problem is one of, you know, there is an intrinsic risk in any kind of a space venture and you don't want to compound it when it's tied to, you know, a firm business plan. The shuttle was an unknown. We didn't understand it. It wasn't defined. It wasn't flying at the time that we had to commit to flying on the shuttle. Now, we've gotten over that hurdle, we feel comfortable with the shuttle, we understand it, to a very great extent. We understand the people and who we have to play and communicate with in order to get ourselves a decent mission.

As a consequence, introducing additional vehicles, there is an additional expense if we switch or look at several different vehicles at the same time, but more critically there's always the chance of some unknowns cropping up that are going to hit us that we just aren't experienced with, so we shy away from change, I think. And right now we're committed to the shuttle, we view that as a workhorse vehicle and we'd like to stay there.

Mr. **Nelson**. You're saying that when the shuttle was an unknown quantity is when you committed for the payloads on the Ariane?

Mr. **Lyons**. No, no, no, when the shuttle was an unknown commodity I was very reluctant to recommend to our company that we fly on the shuttle, but we got a little carrot and they lowered the price relative to what a Delta was and we got a large stick. They said Delta wouldn't be there anymore.

Mr. **Nelson**. I see.

Mr. **Lyons**. So, with those incentives we went and committed to it.

Mr. **Nelson**. I see, and so now you feel, you say, comfortable with the shuttle.

Mr. **Lyons**. Very much so.

Mr. **Nelson**. Then why did you put a payload on Ariane?

Mr. **Lyons**. We would put a payload on Ariane because we don't like to be single launch vehicle dependent. It was a conscious decision, we perceived Ariane as the alternative launch vehicle in the future, and we wanted to get that type of flight experience. We also have a critical problem in the 1986 timeframe. One of our satellites is going to be retired from service at the very same time that we have a critical need for additional new communications capacity, so we're balancing in our risks. We have one in very late 1986 on the Ariane, followed by a flight in late 1987 on the shuttle, that gives us the assurance it will have the communications capacity in a timely manner, and that was the strategy we employed. There's also a price differential, which if it had not existed, we probably would not have elected to take Ariane. We would not have engaged in this balanced risk philosophy.

Mr. **Nelson**. Do you intend to fly on Ariane in the future?

Mr. **Lyons**. We have committed our sixth satellite to shuttle and we are negotiating with NASA at the present time for that satellite. Beyond that point I'm really not sure what our, you know, our long-term plans will be. We don't have satellites in concept for the subsequent missions, so I can't tell you for sure.

Mr. NELSON. And was the reason that your sixth satellite is going to Ariane, was that the price differential?

Mr. LYONS. No, the fifth satellite went to Ariane and it was influenced by the price differential, but that wasn't the primary reason.

Mr. NELSON. Well, what was the primary reason?

Mr. LYONS. The primary reason was to balance that risk in that 1986, 1987 timeframe. We have the fifth satellite going up at one end of that time and the shuttle sixth satellite going up at the, you know——

Mr. NELSON. The risk that you're describing is that you're not sure you're going to have a spot on the shuttle and you were balancing that risk by opting for an alternative vehicle, is that what you're saying?

Mr. LYONS. Yes, even on the Delta program we had experience where there was significant delays in having a vehicle available to us, and every once in a while there is a problem and you get a shut down for some period of time. That can happen to the shuttle as well. With a man rated vehicle that can be a very sensitive factor that could shut it down for an extended duration. We just had to balance that risk by having an alternative available.

Mr. NELSON. But, you say now that you feel comfortable with the shuttle?

Mr. LYONS. Well, I'm always comfortable with the shuttle, but I will always be trying to balance the risk as far as being dependent upon a single launch vehicle.

Mr. NELSON. Let me understand this, because I know what the original theory of the shuttle was, back in the 1970's, when it was developed. What would it take in the shuttle, so that you would not have to make a decision that you wanted to balance that risk and go fly on a foreign ELV?

Mr. LYONS. That's a very tough question. It is, you know, again we're getting two launch pads at Cape Kennedy, that helps because there can be a pad problem, which is one that, you know, can prevent you from launching for an extended period of time. It's really difficult for me to just sit here and decide those things that the U.S. Government must do to give me the assurance. You know, in the limit there is always that risk factor that something will come. The Apollo fire was an example, and that was approximately a 12-month hiatus in the progress of the Apollo Program as a result of the astronaut's deaths, and you have to respect the U.S. Government for being very concerned about any threat to man's safety, and I guess I anticipate that as being the kind of a problem. Or even internal problems, for instance we had a, PAM-related test firing failure, which frankly caused us a delay on the Delta vehicle, and it was not a Delta, it was our own internal problem in terms of resolving our motor problems, and you know, by trading off the vehicle we have reduced our dependency in that particular area on a solid rocket motor.

Mr. NELSON. Would you feel better about it if there were five orbiters instead of four?

Mr. LYONS. No, I don't believe that really, that does not solve the problem I have, either, you know, from the standpoint of having sufficient orbiter capacity to fly our satellites. Certainly the loss of a single orbiter, I don't think, will cause us a significant problem.

Mr. NELSON. If I were to have closed my eyes while you were talking I would swear that you were Pete Aldridge talking from the position of the U.S. Air Force wanting additional ELV's.

Mr. LYONS. Well, you know, maybe we face common problems in terms of criticality, of need of delivering capacity at the proper time.

Mr. NELSON. You're going to be launching, let's say—let's see, here we are in 1986, 1987 and 1988, how many launches are you going to have?

Mr. LYONS. We have two launches scheduled. One in——

Mr. NELSON. For those 3 years.

Mr. LYONS [continuing]. In 1986, one launch, in 1987 one launch.

Mr. NELSON. In 1988?

Mr. LYONS. Nothing in 1988 at the present time.

Mr. NELSON. And out of those two launches, how many are on Ariane?

Mr. LYONS. One.

Mr. NELSON. One out of two.

Mr. LYONS. Now, that's the first one. Appreciate we have flown four on the—two on a Delta, two on the shuttle and Ariane, followed by a shuttle. When we were flying Delta's that was the game available to us. When we were flying shuttles, the Delta was a backup. You know, it did exist.

Mr. NELSON. What about 1989 and 1991?

Mr. LYONS. We anticipate having flights in that timeframe. I would——

Mr. NELSON. Do you know how many?

Mr. LYONS. Let me—I was going to respond to another question. We have a population—we have five orbital slots. We will be completing that with the fifth satellite filling our five orbital slots. The sixth satellite will replace the first one. Before the year 2000 the other four will need replacing, so between somewhere around 1988 and 1996 we will need four additional launches in order to——

Mr. NELSON. And of those four additional launches, how many do you anticipate will be on Ariane?

Mr. LYONS. I would—you know, again, it is our second vehicle, and I would say in that area we would probably be talking one of those four as being, and that of course depends upon competitive pricing of the strategies, the final resolution of the expendable launch vehicle situation, OK.

Mr. NELSON. OK, any further comments from the committee. All of you have been very, very helpful, both of the panels, we appreciate it, appreciate your indulgence. The meeting is adjourned.

[Whereupon, at 5 p.m., the subcommittee recessed to reconvene at the call of the Chair.]

1986 NASA AUTHORIZATION

TUESDAY, FEBRUARY 26, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met, pursuant to recess, at 9:36 a.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. Nelson. The meeting of the Space Science and Applications Subcommittee will come to order.

Good morning. There is a terrible traffic jam out there, so we will probably have members wandering in here over the course of the morning.

Today we are going to continue our NASA 1986 authorization hearings. Today we are going to turn to the science and applications programs.

Our first witness will be Dr. Burt Edelson, Associate Administrator for Science and Applications. Dr. Edelson will review NASA's budget request for his area of responsibility.

Although this budget generally looks good, we find no new starts in it. We expected to see TOPEX and ISTP and perhaps the gravity probe-B shuttle test. Apparently, these have been postponed, along with the SIRTF and the start of a planetary observer line.

We also have many new starts highly recommended for the future. To name just one, the advanced x-ray astronomy facility was the top recommendation of the National Academy of Sciences Astronomy Survey Committee.

I am concerned that AXAF and other planetary and applications missions are being pushed ahead by the developing bow-wave of postponed missions. That may be the biggest single issue that we will have to deal with here, although there are certainly many other questions.

Now, I would be remiss not to mention the area of remote sensing, where the Nation seems to be at a crossroad. We developed this technology, but now we have to decide whether to push ahead and use it or to turn it over to other nations. If the United States is not going to have an operational remote sensing program, perhaps we should not have a remote sensing research program.

One area looks more promising—interdisciplinary research. NASA seems to have won an uphill fight to establish this program, which will study the Earth as a system, a study that requires many disciplines.

47-635 O—85——15

We are very happy to see this in your budget and hope that this interdisciplinary research continues. In this area, we also hope that you support and coordinate with the International Geosphere/Biosphere Program, Dr. Edelson.

That brings me to our second witness, Dr. John Eddy of the National Center for Atmospheric Research in Boulder, CO. Dr. Eddy is representing the National Academy of Sciences Committee on the International Geosphere/Biosphere Program, which definitely will be an interdisciplinary study. Dr. Eddy will describe the importance and necessity of this program.

Now, let me close by making this simple statement: In the past, this committee and this subcommittee have been strongly supportive of science and applications programs, and as chairman, I intend to carry out that tradition firmly and clearly.

So, Dr. Edelson, we welcome you and look forward to your testimony.

I want to note that my colleague and ranking Republican member, Bob Walker, is on his way. He is tied up in traffic. He has an opening statement for himself and Mr. Lujan, so we will enter those in the record, without objection. We will also have written questions submitted by them to which the witnesses can respond in kind.

[The opening prepared statement of Mr. Walker follows:]

OPENING STATEMENT FOR
HONORABLE ROBERT WALKER
NASA AUTHORIZATION HEARING (OSSA)
SPACE, SCIENCE AND APPLICATION SUBCOMMITTEE
FEBRUARY 26, 1985

GOOD MORNING, MR. CHAIRMAN. IT IS A PLEASURE TO WELCOME OUR WITNESSES BEFORE THE COMMITTEE THIS MORNING.

OUR TOPIC TODAY, THE SPACE SCIENCE AND APPLICATIONS PROGRAM, IS THE HEART AND SOUL OF ALL NASA EFFORTS. THE SCIENCE FUNDED IN THIS PART OF NASA IS THE TRUE CUTTING EDGE. OUR ABILITY TO EXPAND THE FRONTIERS OF MAN'S KNOWLEDGE LIES IN OUR WILLINGNESS TO PROVIDE SUFFICIENT FUNDING FOR THIS PROGRAM.

FRANKLY, I AM CONCERNED. WHILE THE OVERALL FUNDING LEVEL FOR NASA IS ENCOURAGING, WE SEE NO NEW START PROPOSALS THIS YEAR. THERE ARE A NUMBER OF HIGHLY IMPORTANT SCIENCE INITIATIVES WHICH ARE BEING POSTPONED. WHILE I AM ONE OF THE STRONGEST SUPPORTERS OF AN END TO DEFICITS AND A BALANCED BUDGET, I AM ALSO A STRONG SUPPORTER OF THIS CRITICAL SCIENTIFIC RESEARCH.

THE ECONOMIC FUTURE MAN FACES IN SPACE IS VIRTUALLY UNLIMITED. IT IS BOUNDED ONLY BY OUR ABILITY TO GET MAN AND EQUIPMENT INTO SPACE ROUTINELY -- AND TO RETURN SAFELY. WE NEED TO PROVIDE GREATER OPPORTUNITY TO THE SCIENTIFIC COMMUNITY TO REACH SPACE ON A REGULAR BASIS. I PREDICT THAT WITHIN THE DECADE WE WILL SEE THE FIRST OF MANY

NOBEL PRIZES AWARDED FOR SPACE BASED SCIENCE. WE MUST ENCOURAGE THAT POSSIBILITY BY INCREASING FLIGHT OPPORTUNITIES.

FINALLY, I AM CONCERNED THAT NASA IS NOT PLACING SUFFICIENT EMPHASIS ON THE SCIENCE OF MATERIALS PROCESSING. I BELIEVE THAT A SPACE BASED ECONOMY OF ONE TRILLION DOLLARS IS POSSIBLE BY THE YEAR 2010 IF WE PROVIDE THE PROPER ENCOURAGEMENTS AND REMOVE INSTITUTIONAL IMPEDIMENTS. HOWEVER, EVEN IF YOU USE A FAR MORE PESSIMISTIC APPROACH, SUCH AS THE CENTER FOR SPACE POLICY ESTIMATE, WHICH I ASK UNANIMOUS CONSENT TO INCLUDE IN THE RECORD WITH MY STATEMENT, WOULD INDICATE THAT THE LAUNCH SERVICES WILL BE $1 BILLION, ON-ORBIT SERVICES WILL ADD $2 BILLION, REMOTE-SENSING WILL ADD ANOTHER $2 BILLION, ADVANCED COMMUNICATIONS WILL TOTAL $15 BILLION, AND MATERIALS PROCESSING WILL TOTAL $40 BILLION.

THE FUTURE IS CLEARLY IN THE FIELD OF MATERIALS PROCESSING, AND I AM CONCERNED THAT WE ARE NOT DEVOTING SUFFICIENT SEED MONEY TO ENSURE COMMERCIAL SUCCESS.

Mr. NELSON. Please proceed, Dr. Edelson.

STATEMENT OF DR. BURTON I. EDELSON, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE SCIENCE AND APPLICATIONS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY DR. JEFFREY ROSENDAHL, ASSISTANT ASSOCIATE ADMINISTRATOR FOR SCIENCE; AND RONALD KONKEL, DIRECTOR, ADMINISTRATION AND RESOURCES MANAGEMENT DIVISION, OFFICE OF SPACE SCIENCE AND APPLICATIONS

Dr. EDELSON. Thank you, Mr. Chairman and members of the subcommittee.

It is a pleasure to be here this morning to present the fiscal year 1986 budget request for the Space Science and Applications Program.

I have with me this morning Dr. Jeffrey Rosendhal, who is Assistant Associate Administrator for Science, and Mr. Ronald Konkel, who is the Director of the Resources Administration Division of OSSA.

With your permission, Mr. Chairman, I will submit a written statement for the record and present my summary remarks in oral testimony.

The space science and applications program is a vital and exciting one, a major part of the Nation's space program. It involves many scientific disciplines, and it has distinct but related goals: to create new scientific knowledge; to develop new technologies and capabilities; and to apply these technologies and capabilities for the benefit of this country and all mankind.

The fiscal year 1986 budget will support a healthy, active, and balanced program. It will continue the all-important research program; move forward on previously approved flight missions; continue our planning and advanced technology development efforts; and support our active involvement in the space station program.

This budget represents a commitment to maintain U.S. leadership in space science and in the practical applications of space technology and systems. We will maintain the U.S. leadership in these areas that we have enjoyed over the past 25 years.

Let me review very quickly several of the more noteworthy successes of the past year. These include repair, on orbit, of the Solar Max mission in April 1984; the successful launch of the international active magnetospheric particle tracer explorer, AMPTE, in August; launch of the second in a series of Earth observation payloads on the shuttle in October; and the first launch from the shuttle of a scientific spacecraft, the Earth radiation budget satellite, ERBS, also in October.

Time does not permit a detailed discussion of these achievements. However, as examples, Mr. Chairman, I invite your attention to the several posters we have positioned around the room showing results from the Earth observation payloads on the space shuttle in October of last year.

Mr. NELSON. One of those looks quite familiar, Dr. Edelson.

Dr. EDELSON. I thought that would appeal to you. The two over here, Mr. Chairman, are large-format camera images. The one of the eastern coast of Florida there showing KSC is a color photograph. The one on the right is a high-resolution black and white. We also have infrared photographs which are of great interest.

Mr. NELSON. I will bet you didn't know something. Where you can see the 3-mile shuttle runway there—do you see it there, the line?

Dr. EDELSON. Oh, yes, sir.

Mr. NELSON. My family homesteaded one-half mile from the north end of that runway in 1917. You know, that was the old Homestead Act from the 1860's. You could squat on the land for 2 years, and the Government would then deed you 160 acres. Right there, what is now the Space Center, is where my grandfather and grandmother homesteaded in 1917.

Dr. EDELSON. Well, it would be my pleasure to leave that large print with you here, Mr. Chairman. [Laughter.]

Mr. NELSON. I wasn't asking for that, Dr. Edelson. No, I have some photographic images of it.

Dr. EDELSON. Our past achievements in the space science and applications are prolog for the future program. I anticipate great things in our program during the coming year.

I would like to touch now on several points that are basic to our program and critical to an understanding of how we conduct it.

We spend a great deal of time trying to develop the program balance needed to ensure a scientifically successful present and a healthy future. To this end, we have endeavored to support a flight program that will yield excellent results and, at the same time, give the Nation the best return for dollars expended.

We have a carefully considered flight program that is based on the very best advice available in and out of the Government. However, we are also sensitive to the need to maintain the lifeblood of the program—the people and the institutions supported by our research and analysis activities. I am happy to report that we are doing well in both areas.

Let me give you some examples. We recognize that a vital research and analysis program is critical to our future success, and we have made a special effort to ensure that R&A is adequately funded. I believe that the research program in fiscal year 1986 at the level of $406 million demonstrates our commitment and concern and is responsive to the counsel provided by this committee.

I would like to point out that the R&A budget reflected in this request ensures continued support of university investigators and provides significant amounts of instrumentation for university laboratories.

Funding for microgravity sciences and applications is increased significantly in this budget, from $27 million to $34 million in fiscal year 1985 to fiscal year 1986, up 25 percent.

Our program scope has been broadened with two primary goals: to use the microgravity environment of space to gain a better understanding of the physics, the chemistry, and the materials science involved; and to make the results of this basic research available to support practical applications.

We continue to work with private industry, through joint endeavor agreements, to promote commercialization, and we are establishing two centers of excellence in pharmaceutical research and in organic separations, one at the University of Arizona; the other at the University Science Center in Philadelphia.

Life sciences funding is up substantially—15 percent. This will support the increased activity related to space shuttle operations and the space station. The life sciences program provides the scientific, medical and biotechnical base needed to ensure safe and productive manned space flight activities. We also seek to advance our understanding of space-related biological processes.

We are directly involved in planning for the space station. We believe that our future space science and applications program can benefit greatly from the establishment of a permanent manned presence in space. We are already studying the possibilities in detail.

Planned elements such as the pressurized modules, the service and repair facilities, and the polar orbiting platforms will greatly enhance our capabilities in several fields of investigation.

We have established a task force on the scientific uses of the space station under the chairmanship of Prof. Peter Banks of Stanford University. This task force is serving as a focal point for the scientific community to provide advice on how the space station capabilities can be utilized to support science and applications activities.

International cooperation is critical to the long-term health of the space science and applications program. Excellent examples of recent successes include spacelab I, the infrared astronomy satellite, IRAS, and the active magnetospheric particle tracer experiment, AMPTE. Our future plans include many opportunities for international participation and cooperation.

Our space science and applications program is increasing in depth, in scope, and in intensity of effort. We will witness a spectacular year in 1986, including some of the most advanced and potentially rewarding scientific missions ever attempted:

SLS–1, the first dedicated spacelab for life sciences, will fly on the space shuttle in early 1986 to study biological process in the zero-gravity environment and help us to learn more about long stay time in orbit.

We will launch the Galileo mission to Jupiter in May 1986 to conduct a comprehensive exploration of that giant planet, its atmosphere, magnetosphere, and its satellites. It will use both remote sensing instruments and an atmospheric probe.

Ulysses, formerly ISPM, a joint program between NASA and the European Space Agency, will be launched into a trajectory out of the plane of the ecliptic to obtain the first view of the Sun and solar system looking down on the solar polar regions.

Later in 1986, the Hubble space telescope, the centerpiece of our scientific program, will be launched on the space shuttle to gain a vast improvement in our ability to observe and explore much of the universe unreachable with ground-based telescopes.

By any measure, Mr. Chairman, 1986 should be a banner year for space science and applications. These achievements will be a direct result of the carefully planned space science and applications program of past years that is continued with this request. Much of the credit for the Nation's excellent program is a result of the consistent interest and support of this subcommittee.

Our budget request for space science and applications for 1986 is $1,613.2 million. The space applications portion of the request is $551.8 million. The details of the budget request are included in my written statement, and a summary is attached to this overview.

Mr. Chairman, that concludes my statement. I will be happy to answer any questions that you or members might have.

[The prepared statement, plus answers to initial and additional questions asked of Dr. Edelson, follows:]

Statement of

Dr. Burton I. Edelson
Associate Administrator for
Space Science and Applications

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman, members of the Subcommittee:

It is a pleasure for me to be here today to discuss with you the proposed FY 1986 budget for the Space Science and Applications program.

This program is a vital and exciting part of our national space effort. It involves many different scientific and engineering disciplines. It has several distinct but related goals --- to create new scientific knowledge, to develop new technologies and new capabilities, and to apply these technologies and capabilities to benefit this country and all humanity.

To meet these goals, we are involved with the entire universe. We are observing and measuring the distant stars and galaxies, we are exploring our close cosmic neighborhood, the solar system, and we are using the vantage point of space to study the global behavior of our own planet Earth. We are actively concerned with using manned capabilities in space for further experimentation and application in microgravity science, materials processing, and biomedical sciences. We are developing new and valuable remote sensing techniques for investigating the Earth. We are developing advanced technologies for better communications and data management. And we are already planning for a new era in space --- the active use of the Space Station and its associated platforms for increased scientific discovery and practical applications.

HIGHLIGHTS OF THE PAST YEAR

Before presenting the FY 1986 budget, I would like to review with you several of the most exciting highlights of our past year's activities.

PLANETS AROUND OTHER STARS?

Ground-based observations in 1984 supported by our Research and Analysis activities, provided some exciting contributions to the long debate about whether other stars have planets. A disk of solid particles was detected around the star Beta Pictoris, confirming earlier discoveries of such disks by the Infrared Astronomy Satellite (IRAS) two years ago, and studies of the disk suggest that larger, but undetectable, planets may exist close to the star. In December 1984, a body larger than Jupiter was detected circling the star van Biesbroeck 8. Much bigger than any known planet, but smaller and cooler than any known star, this object may be the first "brown dwarf" ever observed, something intermediate between giant planets like Jupiter and the smallest stars.

SOLAR MAXIMUM MISSION (SMM) REPAIR

The spectacularly successful repair of the Solar Maximum Mission (SMM) spacecraft was performed by astronauts on the Space Shuttle 41-C mission in early April 1984. Some important new discoveries in solar physics have already come from the repaired Solar Max. A large flare, observed on April 24, 1984 (only two weeks after the repair mission), displayed the most intense and longest-lasting emission of gamma-rays and hard x-rays ever observed. The new Attitude Control System for Solar Max points the spacecraft better and holds it steadier than the original one, and the change has greatly improved the images and data obtained by several instruments. The successful repair also made it possible to initiate new ground-based operating procedures, one of which has increased the time resolution of the Ultraviolet Spectrophotometer by a factor of ten. As a result, we can now match the variations seen in hard x-rays of solar flares with variations in the ultraviolet.

ACTIVE MAGNETOSPHERIC PARTICLE TRACER EXPLORER (AMPTE)

The successful launch of three spacecraft into Earth orbit by a single Delta rocket in August 1984 initiated the research phase of the international AMPTE program to study the solar wind and the near-Earth space environment. The three spacecraft are the Ion Release Module (IRM) from the Federal Republic of Germany, the United Kingdom Subsatellite (UKS), and the Charge Composition Explorer from NASA. In the fall of 1984, the IRM released two clouds of tracer ions into the solar wind on the sunward side of the Earth. These ion clouds were clearly detected by UKS as they expanded into the solar wind. In December, further tracer ion releases intentionally created an artificial comet in order to understand the basic plasma physics processes in the solar wind. In February-March 1985, additional tracer ion releases will be made in the region of the Earth's geomagnetic tail.

EARTH OBSERVATIONS FROM THE SPACE SHUTTLE

The second in a series of Earth observation payloads (OSTA-3), was flown on the Space Shuttle Challenger (STS 41-G) in October 1984. The payload contained two Earth science instruments, the Shuttle Imaging Radar-B (SIR-B) and the Measurement of Air Pollution from Space (MAPS), both of which were similar to instruments flown in November 1981. A third instrument, the

Large Format Camera (LFC), was flown for the first time. All three experiments successfully met their objectives, although the SIR-B was hampered by problems with Challenger's Ku-band communications antenna.

Although the data processing is just getting underway, the raw science data appears excellent. I'm sure we will have some exciting results to discuss soon.

EARTH RADIATION BUDGET EXPERIMENT (ERBE)

The Earth Radiation Budget Satellite (ERBS) was the first scientific spacecraft launched from the Space Shuttle. It was placed in a 57-degree inclined orbit during the STS-41G flight in October 1984. In December 1984, the NOAA-9 Satellite carried a set of companion instruments into a complementary near-polar orbit. These missions are an essential part of the Earth Radiation Budget Experiment (ERBE), which is intended to determine how much solar radiation is reflected and absorbed by the Earth's atmosphere and oceans. This information is essential if we are to understand the mechanisms behind the Earth's weather and climate.

All of the ERBS experiments are operating exactly as planned as are the companion instruments on NOAA-9. Two of the ERBS instruments are providing a new level of achievement in absolute radiometric measurements. The ground data processing system is in place, and scientifically useful products are being prepared for delivery to the scientific community early this year. Data from the third ERBS instrument, the Stratospheric Aerosol Gas Experiment (SAGE II) have already shown that the excess global aerosols produced by the 1982 El Chichon volcanic eruption in Mexico still remain at levels associated with the peak values of the 1980 Mount St. Helens eruptions, although this material is slowly being removed from the stratosphere. Scattering and absorption of sunlight by this material is expected to produce prolonged and colorful sunsets for some time to come.

These are only a few of the many important and exciting achievements of the past year, but I hope they will give you a feeling for the nature and variety of our activities. I will now turn to the FY 1986 budget request and discuss it in some detail.

BUDGET REQUEST

The total FY 1986 Research and Development request for the Office of Space Science and Applications is $1613.2 million. I believe that this funding level represents a well-structured, balanced program in the space science and applications disciplines. I would like first to touch on some of the highlights of the budget and then to provide additional details on the activities that will be supported.

The budget I am presenting will support the continuation of a scientifically challenging program at our traditional level of excellence. It includes support for continued development of the following missions, scheduled for launch as indicated:

- o The Hubble Space Telescope (HST) (1986).
- o The Galileo mission (1986).
- o The Ulysses mission (formerly the International Solar Polar Mission) (1986).
- o The Gamma Ray Observatory (GRO) (1988).
- o The Venus Radar Mapper (VRM) (1988).
- o The Advanced Communications Technology Satellite (ACTS) (1989).
- o The Upper Atmosphere Research Satellite (UARS) (1989).
- o The Mars Observer mission (formerly the Mars Geoscience/Climatology Orbiter or MGCO) (1990).

The FY 1986 budget also supports continued work in our Explorer Program and the development of instrumentation and other associated mission management activities for the Spacelab and other Space Shuttle missions. It will also support some early development work on instruments and facilities to conduct science and applications missions on the Space Station and its associated platforms. And it will continue our broad-based research and analysis activities in the space science and applications disciplines, including astronomy and astrophysics, exploration of the solar system, earth science and applications, and communications technology and information systems.

I am confident that this budget request will support an outstanding space science and applications program. The details of the FY 1986 Space Science and Applications budget request are displayed on Charts #1 and #2. I will now briefly review some of the major elements of the program.

PHYSICS AND ASTRONOMY

This year we are requesting $630.4 million for our Physics and Astronomy program. This program seeks answers to both the oldest and the newest questions about the universe and our place in it. To search for these answers, we must go above the atmosphere to observe cosmic rays and all electromagnetic radiations from infrared to gamma rays. These observations tell us about the different forms of matter and energy in the universe, about the energy sources of luminous and non-luminous matter, about the forces that sweep matter into its many forms, and about the laws of physics that govern matter and energy under extreme conditions of density, temperature, and pressure. This program carries out missions that investigate the structure, dynamics, and evolution of the universe, its galaxies, its stars, and our Sun. The funding also supports the Shuttle Spacelab mission management instrument development, and Explorer development activities associated with all of our Science and Applications program.

Hubble Space Telescope (HST)

The Hubble Space Telescope (HST) Program has now entered the process known as "assembly and verification" in which the optical telescope assembly, all of the control subsystems and the scientific instruments, are brought together and assembled to undergo system checkout and testing. Funding requested for HST in FY 1986 is $127.8 million. This observatory is the centerpiece of our Astrophysics Program. When it is launched in 1986, it will result in a vast improvement in our ability to observe and explore the rest of the universe.

HST is an international cooperative effort, involving extensive participation by the European Space Agency (ESA). The observatory was designed and developed from the outset to use the capabilities of the Space Shuttle to provide servicing and upgrading on orbit. As a result, the HST is expected to remain fully operational for 10 to 20 years, with on-orbit servicing provided first by the Space Shuttle and then by the Space Station's Orbital Maneuvering Vehicle (OMV).

Several major accomplishments have occurred in HST during the past year. The Optical Telescope Assembly was completed, tested, and delivered on time in November 1984 by the Perkin-Elmer Corporation to the system integration contractor, the Lockheed Missiles and Space Company at Sunnyvale, California. The scientific instruments successfully completed verification and acceptance tests at the Goddard Space Flight Center, and four of the five instruments have also been delivered to Lockheed. In addition, assembly of all the HST systems has begun, and initiation of final functional tests will follow.

We are now entering the final, and in some ways, the most challenging, phase of this important program. Many difficult tasks remain to be completed before launch in 1986. These include delivery of the flight model Fine Guidance Sensors, qualification testing of the remaining electronic modules of the Support System Module, functional and environmental tests of the completed observatory, and completion of the development of the many ground software systems.

Gamma Ray Observatory (GRO)

In FY 1986, we are requesting $87.3 million for continued development of the Gamma Ray Observatory (GRO) mission. When GRO is launched from the Space Shuttle in 1988, it will allow astronomers to observe the most energetic portion of the electromagnetic spectrum and to gain new knowledge about some of the most violent and explosive phenomena in the universe. We have begun to fabricate the GRO instruments and the spacecraft. In FY 1986, fabrication and assembly of the spacecraft will be continued; we will also complete assembly and calibration of the instruments.

Solar Maximum Mission (SMM)

In FY 1986, we are requesting $4.3 million for extended operations of the Solar Maximum Mission (SMM). The SMM spacecraft, successfully repaired by an astronaut team in April 1984, has become fully operational once again, and we have resumed our program of observing solar flares, the dynamics of the solar atmosphere, and the energy output of the Sun. The most significant result of the program so far has been the discovery of a global 155-day periodicity in the occurrence of solar flares. This periodicity was discovered in 1984 by analyzing data taken by SMM's Gamma Ray Spectrometer over the last four years. This long periodicity, much longer than the Sun's 27-day rotation cycle, suggests that the magnetic fields that cause flares to erupt on the Sun's surface may actually be generated deep in the Sun's interior and are not simply localized surface effects.

In FY 1986, we will continue a Guest Investigator Program that was started in FY 1985, which will involve about 20 grants to U.S. scientists to participate in data analysis. We will also support the extensive use of SMM data in two science analysis workshops on specialized topics, each workshop involving 25 to 50 scientists.

Explorer Program

We have requested $55.2 million for the Explorer Program in FY 1986. Design and development will be continued on both the Cosmic Background Explorer (COBE), scheduled for launch in 1988, and the Extreme Ultraviolet Explorer (EUVE), scheduled for launch in 1989. The program will also support continued development of an instrument to fly on the German "Roentgensatellit" (ROSAT) in 1987, as well starting fabrication of flight detectors for a cosmic ray mission called the Heavy Nuclei Collector (HNC). The Explorer Program also supports such diverse activities as the cooperative San Marco project with Italy, the development of flight experiments such as the Cosmic Ray Isotope Experiment (CRIE), and the NASA-sponsored scientific studies of ionospheric and magnetospheric processes using metal vapors released from the joint NASA/USAF Combined Release and Radiation Effects Satellite (CRRES), which is planned for launch in 1989.

One of our most successful projects, the International Ultraviolet Explorer (IUE), launched in 1978, is now entering its eighth year of continuously successful operation. The variety and breadth of its ultraviolet observations have already made a major impact on modern astrophysics, and the management methods developed for IUE will help prepare for the effective use of the Hubble Space Telescope and for following up the IRAS discoveries. We have recently received and evaluated more than 300 proposals for observing time on IUE, submitted by scientists in 31 states and several foreign countries, and we will be supporting the successful proposals in FY 1986.

Cosmic Background Explorer (COBE). The Cosmic Background Explorer (COBE) will observe the faint long-wave (infrared and microwave) radiation in the universe. This radiation now appears as a smooth background over the whole sky, representing a temperature within a few degrees of absolute zero. By detecting minute fluctuations in the intensity and temperature of this radiation, from place to place, we can learn what the structure of the universe was like just a few million years after it formed. This data will help us evaluate the "Big Bang" theory of the formation of the universe and will also help us understand the details of the process. During 1984, the cooling unit for COBE successfully passed its first major leak test. In 1985, cold-testing of the two cryogenic instruments will be conducted. In FY 1986, fabrication of the science instruments will be completed, leading to a launch in 1988.

Extreme Ultraviolet Explorer (EUVE). The Extreme Ultraviolet Explorer (EUVE) was initiated in August 1984. During FY 1986, we will continue to develop the instruments. EUVE will conduct the first survey of a portion of the electromagnetic spectrum that lies between ultraviolet light and x-rays, thus giving us our first look at the universe in a totally new region of the spectrum --- literally in a "new light." The mission is planned for launch in 1988.

In response to an innovative suggestion from industry, NASA is considering a new approach to providing a spacecraft platform for EUVE and other future Explorers. Under this approach, NASA would obtain spacecraft services through a privately-owned and privately-developed platform, which could be shared with commercial users. A Request for Proposal for such a platform was released by NASA to the industry in January 1985.

Roentgensatellit (ROSAT) Instrument. The "Roentgensatellit" (ROSAT) is a cooperative project between the Federal Republic of Germany and the United States, in which Germany will build the spacecraft and an imaging x-ray telescope. This instrument will be similar to the second High Energy Astronomy Observatory (HEAO-2 or Einstein), but it will provide higher-resolution observations of energetic, high-temperature objects in the universe. The U.S. will contribute a focal plane detector that is essentially identical to the High Resolution Imager (HRI) used on HEAO-2. The engineering model of the HRI has already been integrated into the engineering model of ROSAT, and fabrication and test of the flight instrument will be completed in FY 1986. Launch of ROSAT on the Space Shuttle is planned for 1987.

Spacelab Payloads

The Spacelab Payloads activity provides management to facilitate and enhance the use of the Space Shuttle and Spacelab systems, for science, applications, and technology research. In FY 1986, we are requesting $135.5 million for this activity. During the past 3 1/2 years, we have flown more than 20 Shuttle mid-deck investigations, three pallet payloads, one dedicated Spacelab mission, and three partial payloads. All of these payloads involved investigators from the national and international science community. We have also established and utilized the ground infrastructure necessary to assemble and fly Spacelab missions. Now that the first few science missions have successfully flown, we are making changes in hardware, documentation requirements, and other factors in order to improve the responsiveness of the system to the science community and to shorten the lead time for investigators.

Several major science and applications payloads were flown in 1984. The Solar Array Technology payload (OAST-1) flew on STS 41-D in August 1984. This mission successfully demonstrated and evaluated a large, lightweight, deployable/retractable solar array and tested advanced types of solar cells in space.

The Solar Optical Telescope (SOT) program is proceeding towards completion of the final definition phase in May 1985. Major program activities at this time include completing the finalization of interfaces between the instruments and the facility and planning for the development stage. Development phases for both the science instruments and the SOT observatory are scheduled to begin in June 1985 and will continue through the remainder of FY 1986. SOT-1 is scheduled to be launched in 1991.

Major payloads scheduled to fly in 1985 and early 1986 include:

Spacelab-3, which will employ the Spacelab module as a manned laboratory for performing experiments in materials processing, life sciences, atmospheric sciences, and technology.

Spacelab-2, which will carry out investigations in solar physics, high energy astrophysics, infrared astronomy, plasma physics, life sciences, and space technology. This mission will be the verification flight for the "Pallet/Igloo" Spacelab configuration and the Instrument Pointing System developed by ESA.

Two Materials Science Laboratory (MSL-2 and -3) missions, which will utilize the upgraded equipment support structure to carry several diverse experiments: containerless processing using electromagnetic and acoustic levitation, electronic materials processing, microgravity mixing, and solidification of unique alloys that do not mix together in Earth's gravity.

Astro-1, which consists of three ultraviolet telescopes and represents the first major step in Shuttle-based ultraviolet astronomy. These instruments will obtain images and spectra of Comet Halley over the entire ultraviolet region. These results will be combined with data obtained from European, Soviet, and Japanese spacecraft encounters and with ground-based observations made by the International Halley Watch. The telescopes will also be used to study other ultraviolet astronomical objects.

Spacelab Life Sciences (Spacelab 4), which will be the first dedicated Life Sciences mission.

PLANETARY EXPLORATION

We anticipate continued and exciting progress in solar system exploration during the coming year, beginning with the International Cometary Explorer's (ICE) flyby of Comet Giacobini-Zinner in September 1985 and continuing with the close flyby of Uranus and its moons by the Voyager 2 spacecraft in January 1986 and the historic appearance and intensive study of Comet Halley in March-April, 1986.

The FY 1986 budget request for Planetary Exploration is $359.0 million. This request includes funds for continued development of four flight programs: Galileo, Ulysses, Venus Radar Mapper (VRM), and the Mars Observer. It also includes funds for the continued operation of existing spacecraft and for supporting activities.

Two missions are scheduled for 1986 launches on the Shuttle/Centaur --- Ulysses (formerly the International Solar Polar Mission) and Galileo. The Galileo mission is planned to encounter Jupiter in late 1988, but we have recently decided to include an option that could return important science results almost immediately by making close-up observations of the 200-km-diameter asteroid 29 Amphitrite as the spacecraft speeds through the asteroid belt in late 1986. A final decision regarding the actual asteroid flyby will be made shortly after launch. All in all, we look forward to a surge of exciting new data in the next two years.

The Venus Radar Mapper (VRM) mission, initiated in FY 1984, and the Mars Observer (formerly the Mars Geoscience/Climatology Orbiter) initiated in FY 1985, have both moved off well in their development efforts toward 1988 and 1990 launches, respectively. These two missions reflect active new thrusts in planetary exploration, following closely the strategy recommended by the Solar System Exploration Committee.

Galileo.

The Galileo mission to Jupiter will conduct a comprehensive exploration of this giant planet, its atmosphere, magnetosphere, and satellites, using both remote sensing measurements from an Orbiter and in situ measurements by an atmospheric probe. The FY 1986 request for Galileo development is $39.7 million.

Significant progress was made over the past year towards the planned 1986 launch on a Shuttle/Centaur. The Galileo Probe completed its acceptance test cycle, was delivered, and was successfully mated and tested with the Orbiter. Orbiter integration, including the retropropulsion module provided by the Federal Republic of Germany, was completed. The combined spacecraft successfully completed its structural/dynamic tests and has satisfactorily completed a significant portion of the hardware/software system tests required before launch. Development of modifications necessary to prevent cosmic-ray-induced "single event upsets" in some of the sensitive electronic devices in the attitude control computer has been completed. The changes are now being implemented at the spacecraft and system levels.

FY 1986 funding will support final pre-launch calibration of the instruments and final integration tests of the flight software. Delivery of the integrated Orbiter and Probe to the Kennedy Space Center is scheduled for January 1986. The FY 1986 funding is also required for on-orbit checkout of the Galileo system after launch.

Ulysses.

In FY 1986, we are requesting $5.6 million for the Ulysses mission, a joint program between NASA and the European Space Agency (ESA). ESA will provide the spacecraft and part of the scientific payload. NASA will provide some of the experiments, the launch operations, and tracking support. Ulysses will obtain our first view of the Sun and the solar system from above, looking down on the Sun. By making comprehensive measurements over a wide range of solar latitudes, the mission will also study in detail the solar magnetic field and the streams of ejected solar wind and solar flare particles. The data obtained will provide fundamental knowledge about the Sun and will give us a better understanding of the effects of solar activity on the Earth's weather and climate.

In FY 1984 the spacecraft was placed in storage until the start of launch preparations. Also during FY 1984, a retrofit of the U.S-provided instruments was initiated; this process will be completed in early 1985. Shipment of the spacecraft to KSC is planned for late 1985. FY 1986 funding will support U.S. investigators to undertake mission planning, testing of instruments with the ESA spacecraft, ground system development activities, and initial on-orbit checkout after launch.

Venus Radar Mapper (VRM).

The VRM mission is designed to map the entire surface of Venus with radar from an orbiting spacecraft and to obtain a ground resolution of less than one kilometer. The program, started in FY 1984, has made good progress in preparing for launch in April 1988 on a Shuttle/Centaur combination. In FY 1986, $112.0 million is requested to continue VRM development.

The validity of the VRM science goals has been confirmed by the radar data returned from Venus by the recent successful U.S.S.R. Venera 15 and 16 missions. The Venera images show a geologically young and active landscape, but they also reveal unexplained features that require better ground resolution to be explained. VRM radar images will have a resolution about 10 times better than those obtained by the Venera missions, and VRM will map virtually the entire planet; Venera coverage is limited to about the northern one-third of the globe.

In FY 1984, contracts were signed with the Martin Marietta Corporation in Denver, Colorado, for the spacecraft system and with the Hughes Aircraft Company in El Segundo, California, for the radar instrument. Thirty-three scientists were confirmed as investigators for the mission, and the mission design was refined with their help. Optimization of the radar design achieved a factor of 1.6 improvement in ground resolution over that originally planned. This improvement will produce better images and will make possible the detection of smaller details on the planet's surface. The project successfully completed its preliminary design review in 1984.

FY 1986 will see a transition from design effort to fabrication, assembly, and testing. The project will complete all design efforts for the spacecraft, radar instrument, and mission operations. Critical design reviews will be held in 1985 before fabrication of flight hardware begins. Fabrication and testing of the radar development model will continue during the year, fabrication of the single flight model radar will begin, and fabrication and testing of the spacecraft subsystems will start.

Mars Observer.

The Mars Observer mission, approved as a new start in FY 1985, is the first of a series of missions recommended by the Solar System Exploration Committee as "planetary observers" to explore the inner planets. The Mars Observer will be our first return to Mars since the Viking missions in 1976. Mars Observer will utilize a modified Earth-orbital spacecraft design and will carry instruments that generally have previous spaceflight heritage. The FY 1986 request for continued Mars Observer development is $43.8 million.

Mars Observer is planned for launch in the latter part of 1990, with arrival at Mars approximately one year later; it will carry out continuous multi-instrument mapping of the planet from a close, nearly circular, nearly polar orbit for a full martian year (687 Earth days). Mars Observer will study the complex inter-related problems of martian geology, geophysics, atmosphere, and climate on a global basis, building on the knowledge --- and the questions --- developed by the Viking mission.

A Request for Proposals to industry for the Mars Observer spacecraft, and an Announcement of Opportunity to the scientific community to propose experiments will be issued in the spring of 1985. In FY 1986, we plan to select and confirm the experiments for the science payload, to select the spacecraft bus, and to award the contract for its development.

Mission Operations and Data Analysis.

This program currently supports five operating spacecraft: Voyagers 1 and 2, Pioneers 10 and 11, and the Pioneer Venus Orbiter. Minor support is also being provided for the International Cometary Explorer (ICE) encounter with Comet Giacobini-Zinner in September, 1985.

Voyagers 1 and 2 are now traveling through the outer solar system on trajectories that will eventually take them into interstellar space. Voyager 1, already beyond the orbit of Uranus, continues to provide data on the interplanetary medium. Voyager 2 will make a close encounter with Uranus in January 1986, the first time this distant planet has ever been visited by a spacecraft. ICE (formerly designated ISEE-3) is on a trajectory to fly through the tail of Comet Giacobini-Zinner in September 1985, the first encounter of any comet by a spacecraft.

Pioneers 10 and 11 continue to explore the outermost reaches of our solar system. Pioneer 10 will soon enter the unexplored region beyond the orbit of Pluto. The Pioneer Venus Orbiter (PVO) spacecraft is still studying Venus from its highly elliptical orbit, and it is obtaining data from new regions of the planet's atmosphere and ionosphere. In January-February 1986, the spacecraft will be reoriented to allow it to make unique ultraviolet observations of Comet Halley, the only opportunity to observe the comet when it is hidden from Earth during its closest approach to the Sun.

In FY 1986, we are requesting $95.0 million to support mission operations and data analysis. These funds have been increased over FY 1985 levels in order to support major activities that take place in FY 1986 --- the Voyager 2 encounter with Uranus, and the initial operations of the Galileo and Ulysses missions, which are scheduled for launch in early 1986. These funds will also support continued Voyager and Pioneer operations, including the planned extension of the Voyager 2 mission to a 1989 encounter with the planet Neptune.

EARTH SCIENCE AND APPLICATIONS

In FY 1986, we are requesting $392.4 million to support Earth Science and Applications investigations. Included within Earth

Science and Applications are programs identified under the Solid Earth Observations and Environmental Observations budget lines. Solid Earth Observations efforts are mainly concerned with investigations of the land/solid areas of the Earth and the Environmental Observations efforts emphasize the scientific studies of the oceans, atmosphere, and magnetosphere. The goal of this program is to understand the many interacting mechanisms involving the Earth and its near-space environment --- the energy received from the Sun, interactions between atmosphere and oceans, the movement of large crustal blocks, and the dynamics of the Earth's magnetic field. We study these processes with a combination of spacecraft missions and ground-based supporting research, in order to understand them well enough to develop predictive models for such phenomena as crustal movements, weather, and climate.

Upper Atmosphere Research Satellite (UARS).

The Upper Atmosphere Research Satellite (UARS) is the next important step in a comprehensive program of research, technology development, and monitoring to understand the effects of human activities on the atmosphere. UARS, approved as a new start in FY 1985 and scheduled for launch in 1989, is the critical element in NASA's overall stratospheric research and measuring program. The mission will provide the first complete data set on stratospheric composition and dynamics by making integrated global measurements of ozone concentration, other chemical species, energy transfer, temperature, and winds in the stratosphere and mesosphere.

We are requesting $134.0 million in FY 1986 for continued development of UARS. Last year, design of the ten UARS scientific instruments progressed as planned, and all preliminary design reviews were satisfactorily completed. Eight of these instruments are domestic, and two are being provided by foreign countries, one from the United Kingdom and one as a joint endeavor between Canada and France. In late 1984, General Electric's Space Systems Division in Valley Forge, Pennsylvania, was competitively selected to carry out the observatory development and system integration phases of the program.

During FY 1986, instrument design for UARS will approach 90 percent completion, and we expect to complete five of the instrument critical design reviews. The Observatory preliminary design review is scheduled for May 1986. The 20 domestic and foreign Principal Investigator teams will continue to be involved in our design coordination activities and will also continue to develop their individual science data interpretation techniques.

Scatterometer.

Our FY 1986 budget request includes $31.7 million to continue development of a Scatterometer, a radar instrument to be flown on the Navy Remote Ocean Sensing Satellite (N-ROSS) in 1989 to make accurate global measurements of ocean surface winds. In addition to satisfying Navy operational requirements, these data will make possible the first global study of the influence of winds on ocean circulation and will provide the basis for improved marine forecasting. Design and development activities of the Scatterometer were initiated in 1984 and are continuing in FY 1985. These activities will continue in FY 1986, leading to a critical design review and to the completion of the engineering model of the Scatterometer instrument. An Announcement of Opportunity for scientific investigations has just been issued, and we expect to select the first group of investigators in November 1985.

Earth Radiation Budget Experiment (ERBE).

We are requesting $2.0 million to continue the Earth Radiation Budget Experiment (ERBE) in order to measure how solar energy is absorbed, reflected, and re-emitted by the Earth's atmospheres and oceans. This information is essential if we are to understand the mechanisms behind our weather and climate. The program achieved a major goal in 1984, with the launch of the Earth Radiation Budget Satellite (ERBS) by the STS 41-G mission. The instruments on ERBS are operating exactly as planned. During FY 1986, the ERBE science team will continue to collect, analyze, and archive the ERBE data; in addition, the last set of ERBE instruments will be launched on NOAA-G.

Other Projects.

The budget request contains $4.5 million for continued development of payloads for the Tethered Satellite System (TSS), a joint program with the Italian government. The National Research Council of Italy will provide the satellite for TSS, and NASA will provide the deployment mechanism and overall systems integration. TSS will open new areas of scientific research not currently possible because tethered experiments can be extended upward or downward from the Space Shuttle's orbital altitude. A payload, lowered 100 kilometers below the Shuttle to 180 kilometers altitude, can globally study a region of the Earth's atmosphere which is presently accessible only by occasional rocket flights; the same payload can also make high resolution crustal geomagnetic measurements. Furthermore, a conducting tether can be used to generate large amplitude hydromagnetic and electrodynamic waves to study space plasma phenomena. The FY 1986 budget for TSS will support continued development of instrumentation to be flown on the first TSS mission to gather scientific data and to evaluate the capabilities of TSS.

We are also working on several projects to expand our ability to observe the Earth's surface from orbit and to increase the yield of scientific data obtained from such remote observations. We are now in the process of planning to upgrade the Shuttle Imaging Radar (SIR) from the SIR-B instrument (which flew in October 1984) to SIR-C. This new instrument will be able to operate at several different radar frequencies and in several different polarization modes. One of the anticipated gains from these new capabilities will be a better characterization of ground vegetation from oribt. The first flight of SIR-C is tentatively planned for late 1988.

A complementary instrument, the Shuttle Imaging Spectrometer Experiment (SISEX) will be a major improvement over earlier experiments for observing the Earth's surface at different wavelengths. SISEX will make rapid multispectral characterization of multiple separate ground points and the experiment will be, in fact, the first flight of an imaging spectrometer for orbital remote sensing of the Earth. The increased data yield will produce important benefits in a wide range of scientific disciplines. The flight of SISEX is tentatively planned for 1989 or 1990.

LIFE SCIENCES

In FY 1986 we request $72.0 Million to continue the Life Sciences Program. This program has two major goals: to provide the scientific, medical, and biotechnical base needed to insure safe and productive manned spaceflight activities and to conduct fundamental research to advance our understanding of space-related biological processes.

A major effort in our program is to understand and counteract the adverse physiological changes that occur in humans during the weightless environment of space flight. Intensive investigations are now underway, both in space and in ground-based laboratories, to develop and test countermeasures that will facilitate the transition of human beings into space and back to Earth again. These studies, which have immediate application to the Space Shuttle Program, are also part of our preparation for long-term missions in the Space Station era.

Basic research in Life Sciences is aimed at several problems of both scientific and practical interest: the interactions between life and gravity, practical food production in space to minimize resupply problems, and understanding the origin, evolution, and distribution of life and life-related molecules throughout the universe. Life Sciences is also a strong participant in the interdisciplinary NASA program directed at understanding biological influences on the chemical, geological, and atmospheric interactions required to sustain life on Earth.

In FY 1986, Life Sciences will use the Spacelab module to conduct the first dedicated life sciences mission (Spacelab 4), scheduled for launch in early 1986. Spacelab 4 will contain the most comprehensive set of biomedical investigations ever assembled in space. These investigations are designed to gather the inflight data required to help solve existing Space Shuttle operational problems; they will also build the investigative program needed to resolve known medical problems of long-term space flight and to understand the effect of gravity on living organisms. The unique, space-qualified biomedical equipment developed for this mission will also be used for life sciences investigations on other future Spacelab missions, such as the International Microgravity Laboratory and the cooperative Japanese (J-8) flights.

The FY 1986 Shuttle missions will also include basic gravitational biology experiments focused on understanding animal and plant gravity perception and the effects of gravity on animal and plant structure and development. In addition, we will initiate research on a demonstration model for a regenerating life support system and will prepare for the development of a flight unit for the early 1990s.

Ground-based biomedical efforts during FY 1986 will emphasize acute operational medicine problems aboard the Shuttle and will intensify preparation efforts for Space Station. The primary focus of Shuttle biomedical research will be directed toward resolving space adaptation syndrome problems, especially space motion sickness. Other efforts focus on reducing the risk of "the bends" during extravehicular activities, developing countermeasures to bone mass loss problems, and improving non-invasive diagnostic and imaging devices. In addition, emergency and health maintenance requirements for the Space Station will be developed and refined.

MICROGRAVITY SCIENCE AND APPLICATIONS

In FY 1986, we are requesting $34.0 million for Microgravity Science and Applications activities. The program scope has been broadened to concentrate on two primary goals: first, to use the microgravity environment of space in order to understand better the basic phenomena of physics, chemistry, materials science, and materials processing; second, to use this basic research to develop practical applications. In FY 1986 we will continue both a flight program and ground-based research in the areas of metals and alloys, electronic materials, glass and ceramics, biotechnology, combustion science, fluid dynamics, and transport phenomena. Ground-based experimental capabilities (drop tubes, drop towers, and aircraft) will support both scientific and commercial participants in the program.

An enhanced flight program utilizing the full capabilities of the Space Shuttle will also be pursued. The current Space Shuttle system can provide an environment of approximately 10^{-4} g's for periods of up to 10 days, in both the Middeck Locker Facility, where small experiments can be accommodated, and in the Shuttle Orbiter Bay, where larger experimental facilities are available. A more advanced carrier known as the Materials Science Laboratory is currently being built and is expected to be flown in 1985. A third capability is the use of the Spacelab, with experiments located either within the module (where they will be operated by the flight crew) or on outside pallets (where they will be operated in an automated mode). We are also planning a series of Spacelab flights called the International Microgravity Laboratory, to utilize instrumentation that is available not only in the United States, but in Europe and Japan as well.

We are working on three commercial Joint Endeavor Agreements (JEAs) in conjunction with the Office of Commercial Programs: one with McDonnell Douglas to develop the continuous-flow electrophoresis process; the second with Microgravity Research Associates for the production of gallium arsenide crystals using electroepitaxial growth; and the third with the 3M Corporation in the area of diffusive crystal growth.

Two centers to support ground-based research on space-based manufacturing of pharmaceuticals and separation of organic materials were selected in 1984, one center to be established at the University of Arizona, and the other, in which 12 universities will participate, to be established in the University City Science Center in Philadelphia.

COMMUNICATIONS

In FY 1986 we are requesting $106.2 million for Communications to continue the development of components, devices, and systems technology required by NASA, other government agencies, and United States industry for advanced communications satellite systems. Specific programs are the Search and Rescue Program and the Advanced Communications Technology Satellite. Other activities include technical consultation, experiment coordination and operations, and a strong research and analysis effort on new technologies.

Advanced Communications Technology Satellite (ACTS).

In FY 1986, we are requesting $90.0 million to continue development activities on the Advanced Communications Technology Satellite (ACTS) program. This program will develop the high risk technologies required to ensure continued U.S. pre-eminence in the field of satellite communications. Launch of the satellite by the Space Shuttle is scheduled for late 1989. A contract for design and development of the flight and ground systems needed for technology validation for the ACTS Program was signed with RCA in August 1984.

In FY 1986, we will continue design and development activities on the communications electronics package, the baseband processor, the multibeam antenna and the spacecraft bus. We will also initiate development of the ground station and associated software.

Satellite-aided Search and Rescue (SARSAT).

We are requesting $1.3 million to provide systems engineering support for the Satellite-aided Search and Rescue (SARSAT)

Program. The International COSPAS/SARSAT project successfully completed its demonstration and evaluation phase during 1984. The system is now in regular use to assist actual search and rescue operations, and more than 350 lives have already been saved. A new Memorandum of Understanding was signed in 1984 by the U.S., Canada, France, and the U.S.S.R. to begin the operational phase of the program, in which four satellites will be operated on a regular basis. Ten ground stations are now operational. FY 1986 activities will include improvement of ground system data handling, development of new types of distress transmitters, and experiments to explore the possible use of geosynchronous and polar-orbiting satellites as instrument carriers.

Technical Consultation and Support Studies.

Unique analytical tools and techniques are now being used to solve problems of satellite/terrestrial system interference and to provide the technical basis for regulatory and policy studies needed to enable continuing orderly growth of existing and new satellite services. In FY 1986, we will perform specific studies to support other U.S. Government agencies in their preparations for the 1985-1988 World Administrative Radio Conference (WARC) on geostationary orbit planning, and the 1987 WARC on mobile communications.

Applications Technology Satellite (ATS).

Two NASA Experimental Spacecraft, Applications Technology Satellites (ATS-1 and -3), despite their combined age of 35 years, continue to provide humanitarian services. ATS-1, which reaches more than 23 locations throughout the Pacific, will continue to provide communications support for health and community services, as well as for scientific experiments. ATS-3 provides similar services in the Western Hemisphere, but on a smaller scale, and it will continue to be an important link for emergency communications in the U.S.

INFORMATION SYSTEMS

For FY 1986, we are requesting $19.2 Million to continue our multi-disciplinary Information Systems program. This program supports all of Space Science and Applications flight projects and science programs by managing major computational resources and by developing the advanced technologies needed for efficient management of the massive amounts of data acquired from missions.

Large scale computer data processing systems used for computations and modeling by researchers include the NASA High Speed Vector Computing Facility (NHSVCF), the Science and Applications Computer Center (SACC), and the Massively Parallel Processor. In addition, the program is responsible for the National Space Science Data Center (NSSDC), which archives all NASA's satellite and rocket data. These systems and facilities are all located at the Goddard Space Flight Center (GSFC).

In FY 1985, we consolidated the SACC and the NHSVCF into a single GSFC facility to permit more efficient and cost-effective sharing between these major computer systems and we will be upgrading the NSSDC facility to be more responsive to the science community's needs for improved data storage, accessibility, and dissemination.

In FY 1986, we will continue to develop improved systems capabilities for space data management, processing, and distribution; we will also provide technical consultation in key programs, such as the Space Station. Emphasis will be placed on our Pilot Data Systems program, which consists of discipline-oriented testbeds used to evaluate and demonstrate new, efficient, and cost-effective computer technologies and to provide a foundation for operational systems. This program has already proven very successful in demonstrating new capabilities for space data analysis and multi-disciplinary correlative research. For example, the Ocean Pilot will become a key data analysis element in the N-ROSS and TOPEX missions now under study.

SUPPORTING PROGRAMS

Our supporting programs in Suborbital Research and in ground-based Research and Analysis provide the essential foundation for all our flight mission activities. Suborbital flights of balloons, sounding rockets, and aircraft continue to provide important observations and research results that complement more complex space missions. The Spartan carriers, a more recent development, can be deployed from the Space Shuttle for longer periods of time, up to 40 hours. Such flights also make it possible to test new instruments and observational methods before undertaking the larger development effort needed to design, build, and fly a major Earth-orbital experiment.

The ground-based Research and Analysis program provides an even wider range of essential support functions: theoretical studies, laboratory research, instrument definition and development, complementary ground-based observations to support flight missions, and extended data analysis from completed missions. The latter task is especially critical, for the analysis of data during the mission itself cannot extract all the available information, and many major discoveries are made from continued analysis of data years after the mission has been completed. These supporting programs also provide a significant fraction of the basic research support to the university, government, and industrial scientific researchers who make up the heart of the Space Science and Applications program.

Suborbital Research.

During the last 18 months, we have experienced a number of problems with our heavy-lift balloons which we are beginning to overcome. Despite these problems, we were able to launch 44 scientific balloons in FY 1984 to support upper atmospheric science, astrophysical research, and solar physics. In FY 1985, we plan to launch nearly 55 balloons, most of them from the Scientific Balloon Facility at Palestine Texas. In FY 1986 we also plan to launch about 55 scientific balloons. We launched 40 scientific sounding rockets in FY 1984, and we plan to launch approximately the same number in FY 1985 and in FY 1986.

The first flight of the new Spartan experiment carrier is scheduled for 1985. This mission will be the first of a series that will use the Space Shuttle to extend the capabilities of our normal sounding rocket payloads by providing up to 40 hours of observing time in Earth orbit. Spartan 1 will carry an x-ray telescope to observe hard x-rays emitted by clusters of galaxies and by a supernova remnant. Spartan 2 will observe Comet Halley with an ultraviolet telescope in early 1986. Other Spartan missions are now under development.

The Airborne Science and Applications program maintains a small number of aircraft as platforms to collect scientific data and to test concepts and prototypes for instruments that will later fly in space. These aircraft, based at the Ames Research Center, include an instrumented Lockheed C-130, three high-altitude Lockheed U-2 type aircraft, a Convair 990 "flying laboratory" and a Lockheed C-141 (the Kuiper Airborne Observatory or KAO). Last year, these aircraft flew approximately 2300 hours to support field experiments and airborne observations for Earth sciences, planetary sciences, life sciences, and astronomy. We expect to provide a similar number of flight hours in FY 1986. In FY 1986, the KAO will turn its 91-centimeter infrared telescope towards many of the new infrared objects discovered by IRAS.

Research and Analysis.

Physics and Astronomy. A major new addition to our research and analysis program in solar physics and astrophysics in FY 1985 is the Astrophysical Theory Program, which will complement the Solar-Terrestrial Theory Program already under way. We are now reviewing the first 48 proposals for FY 1986 funding; they include such fields as cosmology, high energy physics, star formation, stellar physics, and plasma dynamics.

Planetary Exploration. Ground-based observations produced several exciting planetary discoveries in 1984, including the first images of a disk of solid material around the star Beta Pictoris and the first ground-based photographs of the ring system of the planet Uranus. The first spectral data were obtained from the still-distant Comet Halley; the comet is redder than expected, a color that might be due to unknown organic chemicals. Two lines of evidence suggested that there are active volcanoes on Venus: major variations of sulfur dioxide in the atmosphere since 1978, and the detection, using Earth-based radar, of landforms resembling rift valleys and young volcanoes. Closer to home, two more meteorites blasted from the Moon were found by Japanese scientists in the Antarctic.

FY 1986 will see major supporting science efforts to complement the Voyager 2 encounter of Uranus and the flybys of Comet Halley by several foreign spacecraft. The Halley flybys will also be supported by the ultraviolet telescopes on the Shuttle-based Astro mission and by the intense ground-based observational efforts of the worldwide International Halley Watch program.

Earth Science and Applications. In FY 1986, we will continue research and analysis in geodynamics, land processes, ocean processes, atmospheric dynamics and radiation, upper atmosphere phenomena and space plasma physics. We will continue the interdisciplinary research, initiated last year, to study the coupling of processes affecting the land, oceans, and atmosphere.

The Land Processes Program uses remote sensing technology to study physical interactions at or near the Earth's surface. One goal is to determine the various kinds of ecological, geological, and hydrological information that can be derived from remotely sensed data. The other goal is to use this information to better understand those processes, the interrelationships among them, and their effects on the Earth and its surface environment.

During the remainder of FY 1985, this program will continue to analyze data from the Landsat-5 Thematic Mapper, the SIR-B radar, and the airborne sensor program. The program will also support studies of new techniques of data analysis, including pattern recognition and artificial intelligence, in order to develop a more integrated understanding of processes at work on the Earth's surface. In FY 1986, the program, in conjunction with the interdisciplinary research program, will initiate studies aimed at understanding surface climatology and the natural production of methane on land.

Communications. Our efforts in communications research in FY 1986 will continue to develop technologies needed to help the U.S. maintain its competitive edge in space applications communications, to form the basis for new and innovative public services, and to enable new business opportunities for U.S. industry at home and abroad. In FY 1986, we will continue proof-of-concept hardware evaluation and market studies. Specific analyses will focus on future high risk technology needs, development of advanced modems/codecs for on-board switching and processing, spectrum-efficient microwave components, and laser and radio-frequency technology for inter-satellite link communications.

In a special project, we are requesting funds in FY 1986 to continue studies of mobile satellite communications technologies, in order to establish a system for communications links with mobile vehicles. The program will help U.S. industry develop critical technologies to conserve power, frequencies, and orbital slots. These technologies are essential to ensure initiation and growth of the mobile service. The program is expected to evolve into a Joint Endeavor Agreement (JEA) between NASA and U.S. industry.

NASA's interest in mobile satellite communications is shared by Canada; the Canadian Department of Communications (DOC) has an ongoing mobile satellite program in parallel with the NASA effort. In November 1983, NASA and DOC signed a cooperative agreement which provides a framework for NASA and DOC to participate in program definition activities and to work with the respective industries and regulatory agencies in each country to help initiate mobile satellite service. Cooperation between the U.S. and Canada in this area is desirable in order to coordinate selection of frequencies and orbital satellite locations as well as to identify potential cost reductions.

POTENTIAL FUTURE MISSIONS

The Space Science and Applications program continues to support advanced studies of possible future endeavors in order to select and plan missions that are both scientifically important and cost-effective. I would like to mention briefly some of the more exciting possibilities for the future.

ASTRONOMY AND ASTROPHYSICS

The Advanced X-ray Astrophysics Facility (AXAF) is the highest priority for a new orbital observatory in the National Academy of Sciences report, Astronomy and Astrophysics for the 1980s. It will provide new and unique views of high-energy, high-temperature objects in the universe, including clouds of million-degree gas around stars and high-velocity particle jets expelled from galaxies and quasars. We have selected four instruments to be part of AXAF, and detailed definition of these instruments will be started in FY 1986.

The Space Infrared Telescope Facility (SIRTF) will provide the essential tool for detailed studies of the exciting infrared universe recently revealed by IRAS. Last year I mentioned that we were studying the possibility of making SIRTF a long-term observatory. Now I am pleased to tell you that we have chosen this option; SIRTF will be a long-duration orbital facility maintained in orbit by the Space Shuttle, and later by the Space Station. In FY 1985, we selected three instruments for SIRTF, and detailed definition of these instruments will continue in FY 1986.

Advanced research and technology development will continue on aspects of the future Gravity Probe-B (GP-B) instrumentation. The GP-B mission would perform an entirely new test of Einstein's general theory of relativity by using very precise gyroscopes to measure a relativistic twist in the local gravitational field due to the earth's rotation. We will continue to define a test in space for the technology and equipment developed at Stanford University and at the Marshall Space Flight Center. Critical experiment components have been developed and demonstrated in the laboratory, and the long-term gyroscope testing and system-level studies are now under way.

PLANETARY EXPLORATION

Last year the Solar System Exploration Committee (SSEC) completed its three-year study of future planetary exploration by providing recommendations for more valuable and challenging "Augmentation Missions" to complement its earlier Core Program of scientifically valuable, focused, and cost-effective missions. The report on these new missions, which include a Mars Sample Return/Rover and a Comet Nucleus Sample Return, will be available later in 1985.

Last year, our Advanced Studies effort concentrated on the next mission recommended by the SSEC, the Comet Rendezvous/Asteroid Flyby (CRAF). This mission, which is planned for the early 1990s, will use the new modular Mariner Mark II spacecraft. A joint study of the CRAF mission, to define possible cooperative efforts, has been initiated with the Federal Republic of Germany.

EARTH SCIENCE AND APPLICATIONS

The newly-formed Earth Systems Science Committee (ESSC) has already made major progress in defining research needs in the earth sciences and identifying an appropriate role for NASA. In another study effort, we are continuing to review a Global Habitability concept and its relation to the International Geosphere Biosphere Project (IGBP) recently proposed by various groups in the outside scientific community. We have asked the National Academy of Sciences to review and evaluate these two complementary concepts, and we expect a report later in 1985.

In FY 1986, we will continue to study the Ocean Topography Experiment (TOPEX) mission, which would use radar altimetry to provide critical data about the general circulation of the oceans and the nature of atmosphere-ocean interactions. TOPEX is being planned as a joint mission with CNES, the French Space Agency. Our studies will concentrate on maintaining the overlap between TOPEX and the Scatterometer mission now in development to insure a maximum return of comparative information.

To understand better the nature of the Solid Earth, we are also studying a Geopotential Research Mission (GRM) that will measure the Earth's global gravity and magnetic fields with much higher ground resolution.

The International Solar-Terrestrial Physics Program (ISTP), now under study, focuses on Sun-Earth space relations. This program will involve several international spacecraft which will simultaneously observe the Sun and measure the complex behavior of magnetic fields and particle flow that take place in space near the Earth.

SPACE STATION

Our future Space Science and Applications programs can benefit greatly from the establishment of a permanent manned Space Station in the 1990's, and we are already studying the possibilities in considerable detail. Such planned elements of the Space Station as pressurized laboratory modules, servicing accommodation and workshop facilities, and major polar orbiting platforms for coordinated Earth observations will make possible more ambitious activities in many fields of investigation. Many of our ongoing programs have already demonstrated future needs for long-term orbital observations, large power supplies, and high data rate capabilities that can only be provided by the Space Station and its associated platforms.

In addition, the ability of a manned Space Station to carry out such functions as the deployment and recovery of Earth-orbital spacecraft, repair and refurbishment operations, and the staging and launch of deep-space missions will make possible an entirely new range of activities, both in Earth orbit and throughout the solar system. The successful repair of the Solar Maximum Mission spacecraft, which I mentioned earlier, is only a small example of how the scope, lifetime, and scientific value of our future missions can be increased by a permanent human presence in space.

During the current year, we are studying in detail the requirements that our planned activities for the 1990s would place on the Space Station and how our missions could be supported and enhanced by manned and unmanned Space Station elements. We also established last year, through the NASA Advisory Council, a Task Force on the scientific use of Space Station to provide advice on how to optimize the space station capabilities to support science and applications activities.

Other studies and plans are being carried out at the individual discipline level. In Astrophysics, for example, we are examining closely the possibilities for large-scale on-orbit assembly of deployable antennas and astronomical facilities, as well as servicing, parts changeout, and refurbishment of existing facilities on-orbit in order to avoid the costs of returning them to Earth and re-launching them.

In Planetary Exploration, we are examining the possibility of dedicated planetary telescopes associated with the Space Station, including instruments for possible detection of extrasolar planets. The Space Station may also make possible major, scientifically challenging missions by providing spacecraft staging operations and support laboratories for unmanned sample return missions to Mars and the nucleus of a comet.

In Earth Observations, we are actively studying the requirements for an Earth Observing System (EOS) on a polar platform, and a report of the study has just been completed.

The Microgravity Science and Applications program is developing plans for the transition of Shuttle-based instruments to the Space Station and is also developing a Microgravity Research Center at the Lewis Research Center to test ground-based equipment in an environment that duplicates (as far as possible) the Space Station. As the design of the Space Station progresses, this laboratory will evolve into a ground-based test bed which will enable us to check hardware designs as well as enhance the use of Space Station itself. This laboratory will also provide a means by which individuals proposing investigations can explore the suitability and possibilities for their experiments aboard the Space Station.

The Life Sciences program is continuing biomedical research on space adaptation problems and long-term life support in space. Additional expanded efforts involve developing a new generation of non-invasive diagnostic and treatment techniques as a step toward providing medical care and health maintenance capabilities for future long-term space travelers.

In a complementary effort to our Space Station studies, we are also seeking advice from the National Academy of Sciences' Space Science Board (SSB). The SSB acts as the focus of interest for the National Academy of Engineering Research Council in space sciences, and the SSB seeks especially to stimulate research, promote coordination of scientific efforts, and provide advice and recommendations with regard to the space sciences.

The SSB is now beginning a major two-year study of long-term future directions in the space science and applications area, and this study will take into account the new capabilities that the Space Station will provide.

CONCLUSION

In summary, the budget we propose for FY 1986 will support a healthy, active, and balanced program. The program continues our essential ground-based supporting efforts, moves forward on the development of previously approved missions, and continues our active involvement in planning for the use of the Space Station.

As I noted in the beginning, the Space Science and Applications program has established a long tradition of achievement in understanding the universe, learning about the Earth as a planet, and developing new and useful applications of space science and technology. The FY 1986 budget represents a commitment to maintain the scientific and technical excellence that have had such an important impact on the nation and the world. We will continue the outstanding efforts of the past, we will move forward on the development of current missions, and we will assure the preservation of the science research base that is critical to U.S. leadership in space.

OFFICE OF SPACE SCIENCE AND APPLICATIONS
FY 1986 BUDGET REQUEST
(DOLLARS IN MILLIONS)

	FY 1984 BUDGET	FY 1985 BUDGET	FY 1986 REQUEST
SPACE APPLICATIONS – TOTAL	314.0	374.1	561.8
SOLID EARTH OBSERVATIONS			
LANDSAT-4	16.8	–	–
SHUTTLE PAYLOADS	17.0	12.1	23.1
GEODYNAMICS	28.0	29.9	31.7
RESEARCH AND ANALYSIS	14.6	15.6	20.1
SUBTOTAL	76.4	57.6	74.9
ENVIRONMENTAL OBSERVATIONS			
INTERDISCIPLINARY RESEARCH AND ANALYSIS	–	1.0	1.0
UPPER ATMOSPHERE RESEARCH AND ANALYSIS	28.4	31.0	33.0
OCEANIC PROCESSES RESEARCH AND ANALYSIS	18.2	19.4	20.6
ATMOSPHERIC DYNAMICS/RADIATION RESEARCH AND ANALYSIS	27.5	28.5	30.3
SPACE PHYSICS RESEARCH AND ANALYSIS	16.8	16.7	17.8
SHUTTLE PAYLOADS	7.6	7.8	5.6
TETHER PAYLOADS	–	3.0	4.5
OPERATIONAL SATELLITE IMPROVEMENT PROGRAM	0.6	–	–
EARTH RADIATION BUDGET EXPERIMENT	15.5	8.1	2.0
MISSION OPERATIONS	27.4	29.5	37.0
UPPER ATMOSPHERE RESEARCH SATELLITE MISSION	20.0	55.7	134.0
SCATTEROMETER	–	12.0	31.7
SUBTOTAL	162.0	212.7	317.5
MATERIALS PROCESSING IN SPACE			
RESEARCH AND ANALYSIS	11.0	11.7	12.4
MATERIALS EXPERIMENT OPERATIONS	14.6	15.3	21.6
SUBTOTAL	25.6	27.0	34.0

CHART #1

OFFICE OF SPACE SCIENCE AND APPLICATIONS
FY 1986 BUDGET REQUEST (CONTINUED)
(DOLLARS IN MILLIONS)

	FY 1984 BUDGET	FY 1985 BUDGET	FY 1986 REQUEST
COMMUNICATIONS			
RESEARCH AND ANALYSIS	8.5	9.1	10.6
SEARCH AND RESCUE	3.8	2.4	1.3
TECHNICAL CONSULTATION AND SUPPORT	2.7	2.9	3.1
EXPERIMENT COORDINATION AND OPER. SUPPORT	1.1	1.2	1.2
ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE	25.0	45.0	90.0
SUBTOTAL	41.1	60.6	106.2
INFORMATION SYSTEMS	8.9	16.2	19.2
PHYSICS AND ASTRONOMY – TOTAL	**567.6**	**677.2**	**630.4**
HUBBLE SPACE TELESCOPE DEVELOPMENT	195.6	195.0	127.8
GAMMA RAY OBSERVATORY DEVELOPMENT	85.9	117.2	87.3
SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT	80.9	105.4	135.5
EXPLORER DEVELOPMENT	48.7	51.9	55.2
MISSION OPERATIONS AND DATA ANALYSIS	68.1	109.1	119.9
RESEARCH AND ANALYSIS	35.9	39.9	42.3
SUBORBITAL PROGRAMS	52.5	58.7	62.4
PLANETARY EXPLORATION – TOTAL	**217.4**	**290.9**	**359.0**
GALILEO DEVELOPMENT	79.5	56.1	39.7
ULYSSES (FORMERLY ISPM)	6.0	9.0	5.6
MISSION OPERATIONS AND DATA ANALYSIS	43.4	58.8	95.0
RESEARCH AND ANALYSIS	59.5	61.5	62.9
VENUS RADAR MAPPER DEVELOPMENT	29.0	92.5	112.0
MARS OBSERVER (FORMERLY MGCO)	–	13.0	43.8
LIFE SCIENCES – TOTAL	**58.0**	**62.3**	**72.0**
FLIGHT EXPERIMENTS	23.0	27.1	33.4
RESEARCH AND ANALYSIS	35.0	35.2	38.6
TOTAL OFFICE OF SPACE SCIENCE AND APPLICATIONS	**1157.0**	**1404.5**	**1613.2**

CHART #2

Written questions submitted in connection with Dr. Edelson's appearance before the Subcommittee on Space Science and Applications on February 26.

Office of Space Science and Applications

Question 1: Please describe your disposition of the Authorization actions on your Fiscal Year 1985 Budget.

Answer 1: The following is a comparison of the Authorization Committee's recommended actions on the Space Science and Applications FY 1985 budget request and the FY 1985 Operating Plan submitted to the Committee on October 3, 1984.

Physics and Astronomy:

o Authorization Committee Conference Action: Added $19 million to the NASA FY 1985 Budget Request for Physics and Astronomy and recommended that $4 million be used for SOT/SIRTF advanced technology development; $4 million for Space Plasma Lab; $3 million for AXAF advanced technology development; $2 million for theoretical Astrophysics supporting research and technology; $3 million for Gravity Probe-B; and $3 million for university instrumentation and laboratory equipment.

o NASA's FY 1985 Operating Plan: The operating plan total for Physics and Astronomy (P&A) reflects no change from the original budget request; however, there are changes within the total Physics and Astronomy budget line. The Research and Analysis funding reflects an increase of $3.0 million made in consonance with Congressional actions to enhance the Astrophysics theoretical activities, and to conduct AXAF activities; the AXAF Phase B studies were awarded recently and will be conducted over approximately the next 18 months. The augmentation will also be used to enhance university instrumentation. In addition, the Gravity Probe-B Phase B studies will be awarded within the next few weeks; these studies will be conducted over approximately the next twelve months. The Solar Optical Telescope (SOT) activities will also be continued in FY 1985 with initiation of development planned in June 1985, and the Space Plasma Lab development activities will be continued in FY 1985 leading to a planned launch in 1988. In addition, several Shuttle Infrared Telescope Facility (SIRTF) principal investigators were recently selected and an announcement has been published. The $3.0 million increase mentioned earlier was offset by a $3.0 million reduction in the Gamma Ray Observatory development activities which reflects the application of a portion of the general reduction in the R&D appropriation identified in conjunction with the HUD-Independent Agencies Appropriations Act, 1985 (P. L. 98-371). The decrease will be accommodated by the rephasing of program activities within the GRO project.

Planetary Exploration:

o Authorization Committee added $10 million with $8 million for supporting Research and Technology, and $2 million for university laboratory equipment.

o NASA's FY 1985 Operating Plan: (+4.0 million) The increase above the original budget request level reflects an augmentation of $7.0 million in Research and Analysis, consistent with the authorization and appropriation actions, to enhance both the supporting research and technology activities and the university laboratory equipment, offset by a $3.0 million reduction in Mars Observer (previously named Mars Geoscience Climatology Orbiter) development. The reduction in Mars observer reflects the application of a portion of the genral reduction in the appropriations as identified in the HUD-Independent Agencies Appropriations Act, 1985 (P. L. 98-371). The decrease will be accommodated by the rephasing of activities within the Mars Observer project.

Life Sciences:

o Authorization Committee made no change to NASA's FY 1985 Budget Request.

o NASA's FY 1985 Operating Plan: (-1.0 million) This decrease is the result of a deferral of some planned research and analysis activities to accommodate a portion of the genral reduction in the appropriation Act, 1985 (P. L. 98-371).

Space Applications:

o Authorization Committee added $46 million, with $5 million for Materials Processing, $4 million for ISTP advanced technology development, $2 million for University Instrumentation in Space Physics, $2 million for Caribbean crustal movement measurements, and $40 million for ACTS; these increases were offset by a recommended $2 million general reduction in geodynamics and a $5 million reduction in UARS.

o NASA's FY 1985 Operating Plan: (+$30.0 million) The increase reflects the net result of increases in Space Communications (+$40.0 million) to allow for initiation of the Advanced Communications Technology Satellite flight program design and development activities leading to a launch in 1989, and in Materials Processing (+$4.0 million) made in general consonance with authorization action, partially offset by reductions in the Upper Atmosphere Research Satellite (UARS) development (-$5.0 million), the Scatterometer development (-$3.0 million), and the Solid Earth Observations Shuttle/Spacelab Payload development (-$6.0 million). The UARS reduction reflects a slip in the launch of the Navy Remote Ocean Sensing System (N-ROSS) from 1988 to 1989--the Scatterometer will fly on the N-ROSS satellite; and the Solid Earth Observations Shuttle/Spacelab Payload development reduction will be accommodated by the phaseout of NASA activities in the Multispectral Linear Array (MLA) technology development as the technology is being overtaken by the capabilities of other remote sensing instruments such as the solid state planar array technology of the Imaging Spectrometer which NASA has also been pursuing. The MLA represents a technology that originally was intended to provide a transition between the Thematic Mapper and the next generation Landsat technology. As a result of the recent technological progress in sensors, together with revised projections of flight opportunities, it now appears appropriate to bypass the MLA technology and concentrate effort on the Shuttle Imaging Spectrometer (SISEX) as the next major technology development in remote sensing. In addition, the Crustal Dynamics Caribbean initiative will be augmented in FY 1985 to measure the crustal movements, and the International Solar Terrestrial Physics (ISTP) program advanced technology development activities have been enhanced in FY 1985, both in consonance with authorization action.

Question 2: Please describe your actions in response to Section 108 of P.L. 98-361, especially the direction to "enhance ... programs of remote-sensing research and development."

Answer 2: NASA's remote sensing programs for earth sciences and applications continue to receive heightened interest as we define the contributions that could and should be made from the vantage point of earth orbit. To this end, we have enlisted over the past year the assistance of key researchers in the major earth sciences disciplines to provide guidance on the most pressing scientific issues that can be addressed through satellite remote sensing and to help define and prioritize NASA's future programs. Concurrently, we have undertaken an ambitious step in examining the gain in information achieved by integrating multiple sensor techniques first on the Shuttle and subsequently on the Space Station polar platform to enhance the information acquired per view of a particular site, including an assessment of the ingredients necessary to efficiently access and manipulate the historical and rapidly expanding data bases of the earth sciences.

We are also continuing to pursue the global habitability concept introduced in 1982. In this regard, we have taken an important first step by releasing an Applications Notice for Interdisciplinary Research and expect an enthusiastic response to this new approach in studying the Earth as a system. We are continuing to work with the National Academy of Sciences to develop the International Geosphere Biosphere Program (IGBP) and to define NASA's potential role in this arena and have requested the National Academy of Sciences to assist in laying out the appropriate relationships between IGBP and global habitability. We expect the results of this review in the summer of 1985.

In the FY-86 budget, the Solid Earth Observations request includes a $3.5M increase to return this important area of research to a level that will allow an aggressive activity in the study of the physical, chemical, and biological processes occurring on the land surface. In the sensor development area, work continues toward the modification and subsequent flight of an imaging radar with both C- and L-band frequencies, multiple look angles, and dual polarization. In passive remote sensing, two approaches had been identified and were being pursued. One approach (i.e. MLA) was to re-design a Thematic Mapper-type instrument to incorporate solid state detector technology, provide for off-nadir viewing and to accomplish a flight test program in short-duration Shuttle flights as an attached payload. The other approach was to take the more advanced step toward an imaging spectrometer that could provide narrow wave-length interval data from the visible into the infrared portion of the spectrum with approximately 128 channels. A decision was made in September 1984 to eliminate the flight test program of the first approach, but to continue the sub-system technology to a level of maturity to assure readiness for incorporation into a thematic mapper class instrument, and to focus our flight hardware development activities on an imaging spectrometer device. We have now implemented this decision and are proceeding with a program that will result in a flight of this device in the early 1990 time-frame.

The NASA FY 1986 budget request also includes $30M for endeavors that foster commercial use of space. We are working with the Office of Commercial Programs to establish a process for encouraging and enhancing the opportunities available to the private sector in remote sensing.

Question 3a: Please describe your approach to maintaining a balanced space science and applications program in the face of a restricted agency budget and a growing Space Station program.

Answer 3a: In formulating our program every year, we go through a comprehensive planning cycle (see enclosed chart). Our planning activities involve internal discussions together with extensive consultation with our Advisory Committees such as the Space Science and Space Applications Boards, the Space and Earth Science Advisory Committee, the Space Applications Advisory Committee, and the Life Sciences Advisory Committee. These committees provide guidance on major new program thrusts, priorities for new starts, and recommend the appropriate balance between new starts and other activities such as research and analysis. We attempt to take as many of these views as possible into account when we prepare our budget proposals.

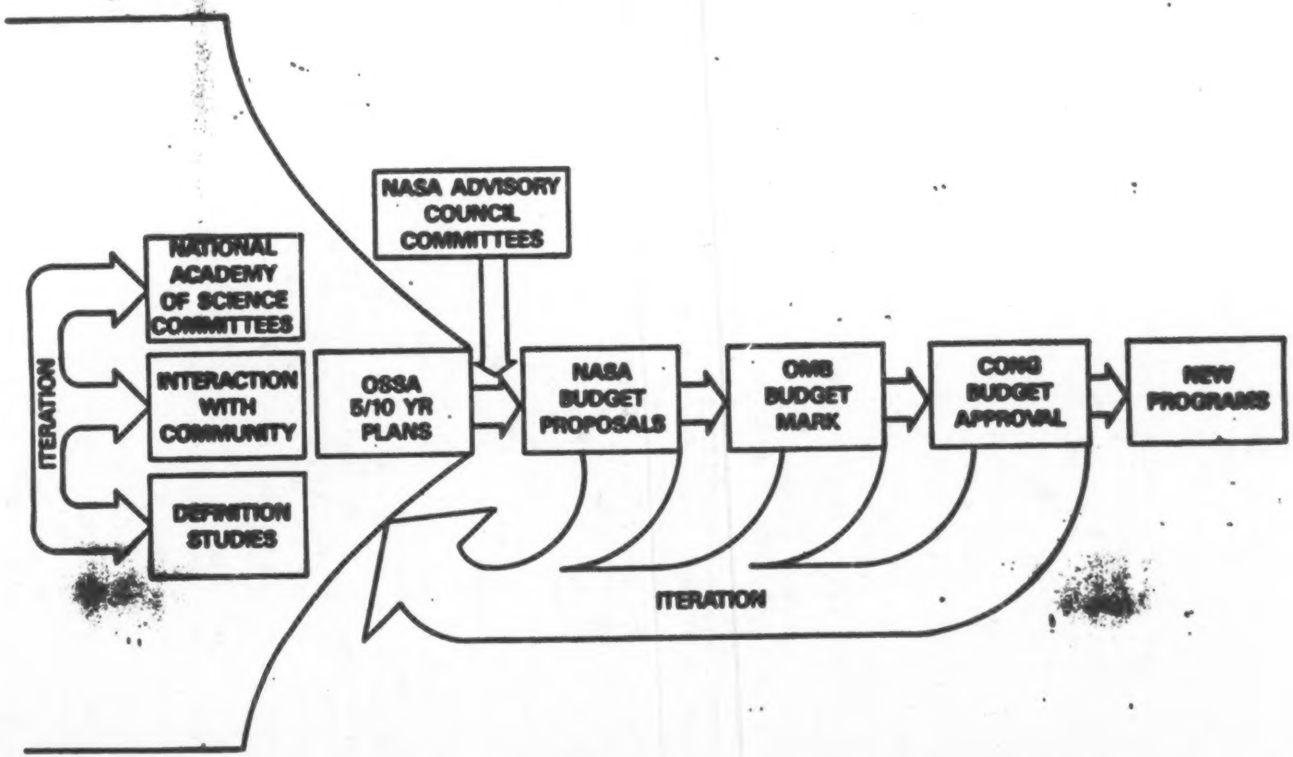
Answer 3b: How do you determine when a program is in balance?

Answer 3b: There is no formula for determining when a program is in balance. In annually examining the detailed content of our budget we look at what activities need to be continued, potential new starts or program augmentations, emerging new areas which need to be fostered, and interplay between work being undertaken in other parts of the program. It is the job of the Office of Space Science and Applications and NASA senior management to ensure that the most pressing needs in all areas of the program are met and that balance is maintained.

Question 3c: What is your reaction and response to the OSTP report stating NASA's space science program overemphasizes astronomy?

Answer 3c: The issue of balance cannot be addressed by looking at a single point in time. Fifteen years ago the space science budget was dominated by the planetary exploration program. Since that time, in recognition of the enormous prospects for advances in astronomy offered by access to space, we started several major new programs in astronomy which have tended to dominate the budget. These programs are now either at or have passed their funding peaks. More recently we have started two new planetary projects and have initiated major new programs in earth sciences and applications. The FY 1986 budget also contains funds for the Solar Optical Telescope which will make an important contribution to our understanding of solar-terrestrial relations. Therefore, the

SPACE SCIENCE AND APPLICATIONS PLANNING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situation is a dynamic one and can only properly be understood by reviewing what happens over an extended period of time.

Question 3d: If you have no new starts this year, how will this affect program balance?

Answer 3d: I do not believe that the lack of new starts this year will have any major impact on program balance. As is our practice, we will continue to examine this issue as we go through our planning activities during the next several months and begin to formulate the FY 1987 budget.

Question 4: The Field Committee recommended that NASA strengthen its support of the Infrastructure of astronomy in the U.S. and the Committee on Science and Technology has echoed this. What steps have you taken in response to this recommendation?

Answer 4: The Field Committee report, particularly the panel on organization, education, and personnel made several recommendations affecting the infrastructure of astronomy in the U.S. NASA has taken steps to implement many of these recommendations. Specifically, we have begun an Astrophysics Theory Program, which will broaden the participation of scientists in the NASA astrophysics program. This will, in turn, contribute to maintaining the base of scientific talent. NASA, in 1985, also expanded its Graduate Fellowship Program, and we expect to receive several applications from astronomy students to participate in this expanded program. In addition, the Congressionally enhanced Research and Analysis budgets have been used to strengthen basic research support at astronomical research institutions and to study new astronomical space missions.

Question 5a: The Committee has requested NASA "to develop selection criteria for each available support platform to better serve the payload community" and report by January 1, 1985. ... To date, what results have come from these two studies?

Answer 5a: NASA's carrier selection criteria report was submitted to the Committee on January 17, 1985. This report, which outlines our current selection criteria, forms the basis of our continuing effort to serve the payload community in an efficient and effective manner by providing payload opportunities on a variety of carriers. In addition, we have made every effort to familiarize potential investigators with the various carrier types in order to minimize expenses related to fitting investigations to particular carriers. Through this effort we feel that our payload community is better served and NASA is effectively providing payload services to the science community.

Question 5b: The Committee has also requested that NASA review astronomy missions and assess the cost, schedule, engineering and scientific implications of carrying out these missions in conjunction with the Space Station. To date, what results have come from these two studies?

Answer 5b: The astronomy requirements study for Space Station is currently being conducted and is progressing well. Some interesting preliminary results indicate that the Space Station system, including platforms, should provide important opportunities for astronomy missions. To pursue the analysis of astronomy Space Station requirements further, NASA is review the Advanced X-Ray Astrophysics Facility and Space Infrared Telescope Facility as two potential candidates for servicing by the Space Station, in addition to several other potential advancements over our existing planned Shuttle/Spacelab payloads.

Question 6: Please describe the method by which the Space Research and Technology program is made aware of the technology needs of the Planetary program. Please document the implementation of this method by describing meetings and briefings (with agenda and attendance) and submit for the record any reports or memos produced as a result of this process.

Answer 6: The Space Research and Technology program is made aware of the planetary program technology needs through a variety of formal and informal technical and programmatic interchanges between the two organizations. These interchanges include the formal documentation of planetary program technology needs, the identification of SR&T program and plans applicable to these needs, participation by a planetary program representative in reviews of technology program developments, SR&T program participation in reviews of planetary mission planning, and formal joint reviews of the process at the Associate Administrator level. However, the majority of the interchanges are at the working level. For example, the Manager of Advanced Programs in the Solar System Exploration Division within the Office of Space Science and Applications and the Assistant Director for Space (Spacecraft Systems) in the Office of Aeronautics and Space Technology (OAST) periodically meet to review the technology development in support of planetary exploration programs. They are currently jointly reviewing a draft of a Planetary Technology Plan which identifies the technology needs, and an Action Plan which specifies the actions planned to meet some of these needs. Meetings were held in the Fall of 1984 by these two individuals with the Directors of the five technology divisions in OAST (Materials and Structures; Aerodynamics; Propulsion, Power, and Energy; Flight Projects; and Information Science and Human Factors) to review planetary technology needs and technology developments, currently underway or planned which may be applicable to these needs. Meetings are also periodically held to discuss the transfer of specific technological developments from OAST to OSSA sponsorship (e.g., on January 29 and February 15, 1985, to discuss the state of technological development required before the transfer of the X-Band Transponder development, the Advanced Digital Synthetic Aperture Radar Processor, and the Fiber Optics Rotation Sensor activities). In addition, within the past three months, the Director of the Solar System Exploration Division within the Office of Space Science and Applications has met several times with the Director of Space in OAST to plan a joint approach to other specific technology developments such as electrical propulsion.

Dr. Edelson, Associate Administrator for the Office of Space Science and Applications (OSSA), and Dr. Martin, Associate Administrator for Office of Aeronautics and Space Technology (OAST), will jointly review the status of SR&T support of OSSA programs including planetary exploration in the Spring of 1985.

PLANETARY TECHNOLOGY PLAN REVIEW NOV. 1, 1984

FLIGHT PROJECTS

Lana Couch gave us a general review of the flight projects role in the OAST program; and outlined the recent and future flight projects including SAFE, IAPS, COFS, Heat Pipe experiments, VOLT, and the Plume Survey. It was suggested that a more detailed review of the results of past experiments would be of interest to a broad audience in the Office of Space Science and Applications. Such a review would help transfer the technical results to agency missions.

It would also be of value to get Code E insights incorporated into the review of proposed flight projects.

Bill Piotrowski pointed out that the COFS beam experiment could be relevant to the SP-100 and wondered if SP-100 requirements were considered. He was also interested in its relevance to future deployable planetary spacecraft.

Lana Couch proposed the idea that some space-on missions spacecraft be used to flight test advanced technology.

Wayne R. Hudson

Wayne R. Hudson

Distribution

RS/L. Harris
   E. Gabris
RX/L. Couch
EL/B. Piotrowski

PLANETARY TECHNOLOGY PLAN REVIEW NOV. 2, 1984

AERODYNAMICS

The current planetary plan is to obtain the probe for the Saturn Orbiter Titan Probe from ESA. Randy Graves was very concerned that the Europeans don't have the knowledge or the facilities to successfully complete such a project.

Wayne Hudson proposed that OAST could provide the SOTP probe. OAST has the worlds best capability in this area. It was pointed out that NASA is more or less committed to obtaining the probe from ESA. An alternate proposal was for OAST to design the probe and for ESA to build it.

The Mars Surface Sample Return mission also will require aeroentry and aeromaneuvering. Randy Graves indicated that this mission will benefit from the technical results of the aerothermal dynamics from the OAST OTV technology program. This effort is budgeted for $3M in FY 1985 and $6M in FY 1986.

Wayne R. Hudson

Wayne R. Hudson

Distribution:

RS/L. Harris
   E. Gabris
RF/R. Graves
EL/B. Piotrowski

PLANETARY TECHNOLOGY PLAN REVIEW NOV 2, 1984

INFORMATION SCIENCE

Lee Holcomb gave a detailed review of the Information Science Program.

The need for coordinated Code E support of the OAST sensor program was discussed at some length. Lee suggested that we work to get a prioritized Code E list of sensors and he would support them. The sensors program should logically generate many handsoff items. It was also pointed out that many of the sensors being developed will require coolers that aren't being developed.

In the area of data compression, Lee pointed out that JPL has several developed compression algorithms on the shelf that could provide a 16:1 compression ratio.

Marty Sokoloski pointed out that the SBIR program was supporting work on a horizon sensor - Ithaco Co.

Holcomb pointed out that JSC has done considerable autonomous rendezvous and docking (SHAPES) is applicable to a Mars Orbiter rendezvous.

It was also pointed out that the Space Station Automation program will provide a sound technical basis for planetary rovers.

Wayne R Hudson

Wayne R. Hudson

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   E. Gabris
RC/L. Holcomb
EL/B. Piotrowski

PLANETARY PLAN REVIEW 10/29/84

MATERIALS AND STRUCTURES

General Comments: The nature of the Materials and Structures Program is very fundamental and generic. There are not many focused items. There may however be opportunities for the Materials and Structures technical experts to consult on specific problems.

Several technical areas were discussed including penetrator technology, TPS for probes, Aeroshells, and Mechanisms.

Actions:

1. Make sure a contact occurrs between Sam Venneri and Byron Swenson of Ames, for the purpose of discussing possible technology support for probes and penetrators.

2. Make sure that Sam gets a review of studies for the Mars Surface Sample Return Mission, either form my self or from Gail Klein.

3. Make sure that a contact occurrs between the planetary program and the M&S Mechanism Program. Sam suggested that they are developing an analytical capability for evaluating mechanisms and this might be of potential use to the planetary mission designers. It was also suggested that the OAST program might focus some of its mechanism work on a problem of specific interest to the planetary program, such as transfering Mars rock samples to the return vehicle.

10/29/84

PLANETARY TECHNOLOGY PLAN REVIEW

POWER AND PROPULSION

General Comments: The Power and Propulsion Program is currently funding work in all areas of interest to the planetary program, the extent of the funding is such that in most cases it is inadequate to assure technology readiness for the mission.

The following subjects were discussed:

1. OAST is not pursuing any work on a battery charge state indicator; preliminary feeling is that this is not presently feasible.

2. OAST is supporting the requirement for long storage life remotely activated batteries with current technology program on Lithium primary batteries at JPL, $1200K.

3. OAST is supporting the requirement for O2-H2 Orbital Injection Module under it's low thrust (2-3,000lbs thrust OTV technology program, $5M,(LERC,MSFC).

4. OAST is supporting work of Arc Jet technology for possible integration in later MMII missions, $500K, JPL.

5. OAST is supporting Power Management work for MMII at JPL at a level of $100K. This level really needs to be increased to have a major impact.

6. OAST is funding an Electric Propulsion program in ion thruster that could support future Comet Nucleus Sample Return at a level of $600K. This effort has been reduced in FY85 because of lack of near term mission application and the current state of the art in ion thrusters.

7. The AMTEC effort at JPL is being supported by OAST, but there is concern that it would require a major development effort to be ready for a mission application,$777K.

8. The OAST solar array program supports future spacecraft power requirements for any future missions, it is being funded at $1300K.

ACTIONS

1. Hold a meeting between Jack Stocky and Frank Stephenson

on items 3 and 4.

2. Determine resources applied to AMTEC.

ISSUES

probes
electrical propulsion
space station

What is the impact on the national technology capability? when the planetary program obtains free subsystems such as propulsion for their missions. Should OAST de-emphasize these areas.

The possiblility of a focused Electric Propulsion program was raised, but it was not thought to be feasible for the 1990 Comet Rendezvous Asteroid Flyby. It is premature to consider such a program for the Saturn Orbiter Titan Probe, and as a result doesn't offer relief from the Ion Thruster Hiatus problem.

Question 7a: Please describe the progress you have made in improving access to space for university scientists and other researchers needing to fly small-to moderate experiments. Please be quantitative if possible.

Answer 7a: To simplify the process of access to space for university scientists, and provide as many flight opportunities as possible, the following capabilities have been developed:

1) Simple orbiter middeck experiment support systems have been developed and are being used to fly experiments on a space available basis. The time required from experiment initiation to flight can be as short as 6 months to 1 year.

2) Utilization of the Get-Away-Special carriers for science experiments also provide a simple, quick response capability for flight. Again, time from experiment initiation to flight could be less than one year.

3) NASA is developing a "hitch hiker" carrier system with fixed interfaces for small, simple experiments. Flights have been scheduled in the shuttle manifest to support such science opportunities. Although limited experiments have been selected at this time, we expect these opportunities to be fully utilized by the science community in the future.

4) The Multipurpose Experiment Support System (MPESS) is now operational and can be configured in several experiment support modes. This system has demonstrated rapid turn-around between missions and provides a unique capability which is being utilized by university scientists to conduct small to moderate size experiments—particularly in the materials sciences area.

5) We are currently developing three Spartan Missions, each with a different scientific instrument. Spartans are a low-cost enhancement of NASA's sounding rocket program which will enable experimenters to increase their flight time from a few minutes to up to 40 hours. These will be low-cost shuttle paylaods flown as autonomous subsatellites, deployed and retrieved by the Space Shuttle. The first Spartan mission is scheduled for 1985 with eleven more through 1988.

6) We are continuing to look at ways of providing opportunities to add experiments to the dedicated Spacelab module missions late in the implementation process. This includes ensuring that all resources including volume, power, crew activities, etc. are not pushed to the "limit" during the early planning and implementation phase.

Question 7b: Specifically, how do you plan to respond to the report of the Shuttle Science Working Group?

Answer 7b: The report of the Shuttle Science Working Group contains a wide variety of suggestions, some of which are actively being pursued, and others are under consideration. While we agree with the general intent and spirit of the report, we have some concern with certain specific recommendations. A response to the Working Group is currently in preparation.

Question 7c: It seems clear that the Space Station science mission model is taking on a life of its own. That is, "desirements" are becoming requirements. In the case of Spacelab a similar process occurred, and what happened was a tendency for all science experiments to grow to the limits of the Spacelab capabilities. The result was a dearth of less-expensive moderate-sized flight opportunities for the kind of experiments a university researcher would fly. How can we keep this history from repeating itself on Space Station?

Answer 7c: NASA's current plans assume continued Shuttle/ Spacelab science payload operations in parallel with Space Station development to allow for flight of as many investigators as possible while involving new investigators along the way to and subsequently allow for the transition of investigators over to the Space Station at the appropriate time.

The Office of Space Science and Applications (OSSA) is currently preparing a moderate Space Station mission model for discussion with both the Space Station Office and the science community which fits within what we believe will be a viable OSSA budget plan during the early years of Space Station operations.

It is expected that with the continuing Shuttle payload opportunities during the Space Station development period, and the attempted matching of scientific expectations with reasonable estimates of projected resources, that the difficulties experienced with the Shuttle program can be ameliorated.

Question 8a: Please concisely state your policy regarding NASA's role in Space Applications.

Answer 8a: NASA continues to support a strong applications program.

In the solid earth and environmental observations programs, we have recognized a clear need to understand the basic physical, chemical, and biological processes of the earth, and the interactions and relationships of the atmosphere and the oceans. In order to have a strong and effective applications program it is necessary to understand the basic underlying science. This important effort to establish a vigorous formulation in these ares does not indicate any reduction in our commitment to a strong applications program. To understand these phenomena, we have a program under development that includes significant activities in geodynamics and the development and use of imaging radars, and the Large Format Camera. We also have a major effort in environmental observations--the Upper Atmosphere Research Satellite--and a vigorous oceans program. These endeavors provide significant potential for practical space applications in the future and are the basis for program growth and development.

The OSSA Communications and Materials Processing activities are strong space applications programs. In Communications, we are pursuing the Advanced Communications Technology Satellite (ACTS), which will develop the technology and techniques necessary for continuing a strong U.S. communications industry. We are also working on technology to maintain the U.S. lead in the mobile communications area. In Materials Processing, we are developing a wide range of techniques and are gaining knowledge regarding the development in space, of metals and alloys, electronic materials, glass and ceramics, biotechnology, combustion, and fluid dynamics and transport phenomena. Private sector interest in the program is growing, and many promising developments are on the horizon.

In our Life Sciences program, there is a significant effort to allow us to understand the effects of space flight on humans, as well as the development of necessary techniques to assure safety and productivity in space. These activities have contributed to new capabilities and procedures in routine medical practice on Earth.

NASA's activities in applications have provided many new capabilities and technologies which improve our productivity and way of life on Earth and are expected to continue to do so.

Question 8b: How do you ensure that Land Remote Sensing Application programs are useful?

Answer 8b: The utility of the application of NASA technology to the environmental and resource management needs of users in the private, government, academic, and international sectors of the land remote sensing community is indicated by the willingness of users in those sectors to invest their own resources in this technology in a cooperative venture with NASA. Such applications programs are considered useful if the user of the technology, after appropriate NASA involvement, invests sufficiently in the technology to ensure future benefits without further NASA involvement.

Question 8c: How does your Applications program interact with NASA's Commercialization Office?

Answer 8c: NASA's Applications Program and the Commercialization Program share the mutual goal of assuring that opportunities for utilizing NASA derived technology and capabilities are available for many sectors (private, academic, and other government) of the economy to incorporate for economic, technology, or efficiency gains. In this regard, NASA's Office of Space Science and Applications (OSSA) and the Office of Commercial Programs have defined a relationship that involves OSSA in an integral role in the solicitation, evaluation, approval, and implementation process for potential endeavors that would draw upon or complement the ongoing OSSA science and applications tasks. This approach will assure the availability of NASA's scientific and engineering talent within the respective disciplines to advise, guide, and provide expertise that will be necessary to enhance the probability of success in accomplishing the commercial ventures.

Question 9: The satellite communication industry is economically strong, but is facing challenges from abroad. The semiconductor industry, in a similar situation, has responded in part by establishing a research consortium to work on common problems. Can you suggest a creative approach whereby NASA could stimulate the formation of some sort of industry consortium to conduct future satellite communications research? Would such an effort be consistent with overall Administration policy?

Answer 9: NASA's current communications program is working with industry in a mode which is as close to an industrial consortium as can be arranged. We involve all aspects of this very competitive and non-monolithic industry in our planning, and hold regular industrial briefings to share the results of our combined efforts. We believe the current approach is working well, and that it is generally recognized as an exemplar industry/government relationship.

Question 10: Please describe the NASA efforts in support of: (i) the U.S. Global Habitability initiative; (ii) the International Geosphere Biosphere Program; (iii) interdisciplinary research.

Answer 10: NASA continues to support a comprehensive Earth Sciences Research Program involving space-based, suborbital, land-based, and sea-based measurements; plus laboratory, theoretical, and instrument and model development studies. Our planned approach regarding Global Habitability activities is to continue relevant on-going NASA research programs such as solar-terrestrial, upper atmospheric, atmospheric dynamics and radiation, and oceanic processes research; expand other relevant programs such as global biology, tropospheric chemistry, and climate research; refocus the land processes program, and pursue interdisciplinary research to advance research in important areas lying between existing discipline areas or those that are critically involved in more than one discipline area. In addition, in FY 1985, NASA initiated development activities on the Upper Atmospheric Research Satellite (UARS), on a Scatterometer which will be flown on the Navy's NROSS satellite, and on an Interdisciplinary Research program. NASA is also pursuing several potential future projects which will enhance our activities in these areas, such as TOPEX (a precise oceanographic topography satellite mission with major international participation); elements of the ISTP (International Solar Terrestrial Physics) Satellite Program, enhancements to elements of ongoing research programs, Geopotential Research Mission (GRM), the Space Station Polar Platform (Earth Observing System), a future Geostationary Earth Observing System, etc.

NASA fully supports the IGBP concept and approach. We have provided, and expect to continue to provide, support to the National Academy of Sciences (NAS), to the IGBP Woods Hole summer studies, and to the study committees formulating the IGBP program.

In addition, at NASA's request, the National Academy of Sciences has agreed to undertake an assessment of NASA's Global Habitability workshop reports and a potential program plan to assess the content, relevance and importance of this approach and to assess how such a concept fits into the World Climate Program, the World Ocean Climate Experiment, and other national and international programs, both ongoing and planned, including the International Geosphere Biosphere Program (IGBP).

As a first step toward implementing an interdisciplinary research activity, NASA has issued a "Dear Colleague" letter announcing new opportunities for scientists worldwide to participate. Three areas of research have been chosen for initial study which are representative of the kind of research to be performed within the

Interdisciplinary Research activity. These are particularly important problems on which progress can be made, while complementing ongoing activities in other related Earth Science programs. These three areas are: (i) a program of research to understand the reasons for the recently discovered increasing trend in the atmospheric concentration of methane and the long term consequences of the increase if it continues, (ii) a land-surface climatology program which is aimed at determining the extent to which changes are taking place in climatologically important properties of the land surface, to quantify those changes in physical and biological terms, to determine the important processes which control the changes, and to determine the overall stability of the coupled land-climate system, and (iii) an ocean basin scale carbon flux program which will develop a better understanding of the magnitude, variability, and fate of carbon fluxes in the oceans on an ocean-basin to global scale, and the role of oceanic carbon fluxes in global scale biogeochemical cycles and climate.

Question 11: Please provide us a copy of this year's annual report on materials processing.

Answer 11: The materials processing annual report is in the final stages of preparation and after completion will be provided to the Subcommittee this Spring.

Question 12: Please describe the FY 1986 funding (and program location) for the following programs:

Answer 12:

PROGRAM	CENTER	FY 1986 FUNDING PLAN
AXAF	MSFC	9-12M
SIRTF	ARC	4-5M
SPL-1	MSFC	4-5M
GP-B Definition	MSFC	5-6M
SOT-1	GSFC	30M
ASTRO-1	MSFC	6-7M
TOPEX	JPL	4-6M
ISTP	GSFC	2-4M
Magnetic Field Satellite	GSFC	100-400K
GRM	GSFC	300-500K
CRAF	JPL	8-10M
Lunar Geoscience Orbiter	JPL	.5-1M
Saturn Orbiter/Titan Probe	JPL	1-2M
SSM	JPL	200-400K
COBE	GSFC	25-26M
Tethered Satellite Payloads	MSFC	4-5M
SL-2	MSFC	4-5M
SL-3	MSFC	2.8-3.5M
Starlab	GSFC	-0-
POF	MSFC	-0-
SHEAL-1	GSFC	1-2M
FUSE	GSFC	7-8M
XTE	GSFC	1-2M
Spartan	GSFC	7-8M
Hitchhiker	GSFC/MSFC	-0-
SETI	ARC	1-2M
Geodynamics of the Carribean	JPL	1-2M
Remote Sensing R&D	GSFC	4-5M

Question 13: Please provide a table of expected launch dates for all science and applications missions now in development (and include known TDRSS launches, Tethered Satellite and Spacelab flights, and LDEF flights.)

Answer 13:

MISSION	EXPECTED LAUNCH DATE
Materials Science Lab-2,3	1985
TDRSS-B,C	1985
LDEF-1 Retrieval	1985
San Marco-D	1985
SL 2,3	1985
Hubble Space Telescope	1986
Spacelab Life Sciences-1	1986
Galileo	1986
Ulysses	1986
Earth Observation Mission 1, 2	1986
TDRSS-D	1986
ASTRO-2, 3	1986, 1987
MSL-4	1986
SPARTAN 1	1987
ASTRO 1	1986
SHEAL -1	1986
SPARTAN 2,3	1986
LDEF-2	1987
Sunlab-1	1987
IML-1	1987
OAST-3	1987
ROSAT	1987
Tether	Currently under revision
Gamma Ray Observatory	1988
Venus Radar Mapper	1988
EUVE	1988
SL-J	1988
Dark Sky	1988
COBE	1988
Upper Atmosphere Research Satellite	1989
Scatterometer	1989
Advanced Communication Test Satellite	1989
Mars Observer	1990

Question 14: The operating costs for Space Telescope seem to be very large, and there are other similar large, long-term science missions in the budget. How do you plan to prevent operating costs from absorbing all your budget.

Answer 14: NASA has initiated studies of the operations of its space observatories (ST, GRO, AXAF, and SIRTF) to identify and define the most cost effective operations procedures. These studies involve examination of scope, implementation modes, and commonality of approach and resources which can be effected. The portion of the budget devoted to operations will be determined in part by the results of these studies. We do not believe that they will consume an excessive portion of the budget but we do currently share your expressed concern.

Questions submitted by Chairman Nelson during the February 26, 1985, hearing

QUESTION E-1:

In 1981 the United States cancelled its spacecraft in the International Solar Polar Mission (ISPM, now "Ulysses"). Last year we agreed with the Europeans and Japanese to conduct an International Solar Terrestrial Physics Program (ISTP) and with the French to conduct a joint ocean topography experiment (TOPEX). These two (ISTP and TOPEX) were anticipated new starts in 1986, but do not appear in the budget.

a. What is the status of ISTP and TOPEX?

b. What has been the foreign reaction to their non-appearance?

ANSWER E-1

a. ISTP has been undergoing a joint planning process with the Japanese and Europeans. The Japanese have received a New Start for the joint ISAS/NASA GEOTAIL mission. ESA anticipates making a selection of SOHO and CLUSTER at the end of 1985 for a 1987 Project Start as the implementation of the Solar-Terrestrial Physics "cornerstone." NASA is presently conducting definition studies on the WIND, POLAR and EQUATOR spacecraft which contribute to the Japanese and European missions as a U.S. portion of the ISTP program which will be considered as a potential candidate for a FY 87 New Start.

b. Both the Japanese and European collaborators have been kept informed about the U.S. ISTP activities. The Japanese are undertaking a one year conceptual design phase on their ISAS mission after which they plan to commit to a full development phase. ESA is continuing to conduct parallel studies for SOHO and CLUSTER which address both ESA-only and ESA/NASA joint missions.

Regarding TOPEX, satellite definition studies are being continued by Fairchild, RCA, and Rockwell. Brassboard development of the TOPEX altimeter is also being continued at the Applied Physics Laboratory. Definition studies are being continued to further define the collaborative responsibilities and interfaces involving CNES and NASA in pursuing the TOPEX/POSEIDON initiative. These activities are being conducted to prepare TOPEX for consideration as a FY 1987 new start candidate.

b. While the French have been concurrently investigating the option of flying their Poseidon instrumentation on SPOT-3, they have stated that they will make a final decision on whether to fly Poseidon on SPOT-3 or TOPEX no earlier than this coming Fall.

QUESTION E-2:

There is a long queue of science missions waiting to start development. Just the most mature prospects include TOPEX, ISTP, GP-B, AXAF, and SIRTF.

a. How do you plan to set priorities for future missions?

b. Are some of the more mature missions likely to be pushed to the end of the queue? Will new missions appear?

c. If new missions move ahead of ISTP, TOPEX, GP-B, AXAF, and SIRTF, what will be the criteria for promoting them (ahead of these missions)?

ANSWER E-2:

a. In formulating future fiscal year budgets and in setting new start priorities, we go through a comprehensive planning cycle every year. Our planning activities involve internal discussions, together with extensive consultation with our Advisory Committees such as the Space Science and Space Applications Boards, the Space and Earth Science Advisory Committee, the Space Applications Advisory Committee, and the Life Sciences Advisory Committee. These committees provide guidance on major new program thrusts, priorities for new starts within the various disciplines, and balance between new starts and other activities such as research and analysis. We attempt to take as many of these views as possible into account when we prepare our budget proposals and set our priorities.

2b. & c: Addressing questions such as these will be an important element of the formulation of the FY 1987 budget request. These are, of course, extremely difficult issues to deal with and a very complex mix of considerations must enter into the assignment of priorities. Our normal approach in formulating the respective fiscal year budget requests is certainly to consider the maturity of all the candidate new starts.

QUESTION E-3:

Some time ago the Solar System Exploration Committee recommended that NASA establish a Planetary Observer program analogous to the Physics and Astronomy Explorer Program.

a. Why has NASA not established a Planetary Observer program analogous to the Explorer Program? We realize that the Mars Orbiter which is in the budget is meant to be in the Planetary Observer class, but the point is that the SSEC recommended that NASA commit to a continuing Planetary Observer program, and this commitment has not been made.

b. When will NASA establish a Planetary Observer program (i.e., what events must occur)?

ANSWER E-3:

a. and b: We believe that the Planetary Observer concept recommended by the Solar System Exploration Committee is most promising. We believe we are pursuing the intent of the SSEC through the initiation of the first Planetary Observer mission, the Mars Observer. The experience we gain in the early phase of the development of that mission will give us the confidence we will need to establish an Observer Program, analogous to the Explorer Program, that utilizes derivatives of an existing Earth-orbital spacecraft to do limited scope focused inner solar system missions.

Specifically, after the Planetary Observer concept has been verified during the first year or so of the Mars Observer development, we will be in a position to seek the full establishment of the Observer Program. The events that have to occur are the verification of the applicability of utilizing an existing spacecraft bus and the identification of instruments that have considerable spaceflight heritage that meet specific mission science objectives.

QUESTION E-4:

The SSEC (see #3) also recommended a "core" program of planetary missions.

a. How many of the core Planetary missions has NASA started? On how many has advanced work begun?

b. The "Core" program was to be minimum. What more is NASA doing?

ANSWER E-4:

a. Of the four highest priority planetary missions recommended by the SSEC, the first two have been approved and started--the Venus Radar Mapper and the Mars Observer. The final building block of the Core Program, the Mariner Mark II missions, will be implemented with the next mission in the SSEC's priority listing, the Comet Rendezvous/Asteroid Flyby (CRAF) mission. CRAF is in the advanced technical definition phase and will be a high priority candidate new start. The fourth mission in the priority listing, the Saturn Orbiter/Titan Probe, is being studied jointly with the European Space Agency as a potential joint undertaking in the 1989 time frame.

We are also conducting science workshops and assessment studies on three Observer-class missions--the Lunar Geoscience Orbiter, the Near-Earth Asteroid Rendezvous Mission, and the Mars Aeronomy Orbiter--in order to select the next candidate Observer Mission following the Mars Observer.

b. The Core Program formulated by the SSEC was intended to establish a long-term, stable base for the planetary sciences in which scientifically exciting missions can be carried out within a realistic, sustainable budget. The SSEC has recommended two augmentation missions in addition to the core program--a Mars Rover/Sample Return mission and a Comet Nucleus Sample Return mission--which could be implemented in the mid-to-late 1990's if the financial climate improves. These augmentation missions are much broader in scope, more technologically challenging, and require a greater commitment than the core missions. We have initiated preliminary mission studies to identify the technology needs and to assess the implementation approaches, including use of the Space Station for staging the spacecraft launch. The SSEC also recommended that a mission operations system be created to handle the operations of all of the missions of the Core Program and that the research and analysis funding level should be restored to the

FY 1981 level. We have undertaken the creation of a multi-mission operations center at the Jet Propulsion Center in response to the SSEC's recommendation, and we have restored the Research and Analysis funding to a viable level to support the Core Program.

QUESTION E-5:

The Field Committee assumed that SIRTF would be developed and recommended that after that a series of new astronomy programs would be started. They also recommended several "prerequisites" (e.g.,support of theory programs) to support the science base.

a. Why is NASA not developing SIRTF?

b. Is NASA achieving the "prerequisites" defined by the Field Committee?

c. How many of the recommended new Astronomy programs has NASA started?

ANSWER E-5:

a. As a result of the success of IRAS, both scientifically and technically, NASA has decided to make SIRTF a permanently orbiting observatory rather than a Shuttle/Spacelab facility. This decision has been overwhelmingly endorsed by the scientific community in spite of the additional time necessary to study the free flyer and space platform mission options. We are continuing definition activities in FY 1985 and FY 1986 with the plan of pursuing SIRTF as a potential new start in FY 1989.

b. Four of the five prerequisites in the Astronomy Survey Committee report apply to NASA, and we are actively engaged in developing each of them.

1. Instruments and detectors. Development work is underway for instruments in every portion of the electromagnetic spectrum.

2. Theory and data analysis. We are just completing the review of 49 proposals submitted in response to our augmentation of the theory program. We expect to begin funding the winners in FY 1986.

3. Computational Facilities. The NASA Astrophysics Division is investigating ways to make image-processing and other computational facilities available to the astrophysics research community as they analyze and interpret data from our major observatories like the Hubble Space Telescope and the Advanced X-ray Astrophysics Facility.

4. Laboratory astrophysics. The NASA Astrophysics program continues to support investigations into astrophysically relevant atomic, molecular, and nuclear data.

c. NASA has augmented the Explorers funding level and initiated cosmic ray experiments, which were two of the seven new program endeavors recommended to NASA by the Astronomy Survey Committee; we have studies underway on all the rest. The status of the programs is as follows:

1. Advanced X-ray Astrophysics Facility is in Phase B and will be a new start candidate in the FY 1987/1988 budget process.

2. Large Deployable Reflector is technically very challenging, and a program to develop the necessary technology is being defined.

3. Augmentation to the NASA Explorer program was received in FY 1984.

4. Far-ultraviolet spectrograph in space is being studied. We are discussing the possibility of developing this mission as part of the Explorer program with participation from the European Space Agency and Australia.

5. Space very long baseline interferometry antenna is being studied as a cooperative program (Quasat) with the European Space Agency.

6. Advanced Solar Observatory is under study, but the first phase involves the development of the Solar Optical Telescope which will be initiated in June 1985.

7. Cosmic ray experiments in space will start with the Cosmic Ray Nuclei Experiment that will fly on Spacelab 2 in 1985. Other cosmic ray experiments are being defined.

QUESTION E-6:

Consider the situation in land remote sensing.

a. Does it not appear possible that there will be no operational U.S. land remote sensing system very soon (because commercialization would fail)?

b. If there is no U.S. Industry to use the technology, for whom is NASA developing its technology?

c. How much money has NASA put into its Landsat program over the last 15 years (approximately)? Approximately, what was the ratio of money for hardware versus money for development of users and "markets"?

d. Since there does not appear to be enough market now to support a private, commerical land-observing system, should we get out of this business?

e. It has been reported (to the NASA Space Applications Advisory Committee) that the Japanese plan to use land remote sensing from space as an instrument of geopolitical power. (i) Who in the United States Government has the responsibility for such considerations? (ii) Has that person or agency considered the importance of land remote sensing to the overall interests and strategic position of the United States?

ANSWER E-6:

a. The NOAA Landsat operational system should last until at least March 1987 based on a 3 year life of Landsat 5; it will probably last much longer. Neither NASA or NOAA have currently programmed funds for a follow-on Landsat series of satellites. Should commercialization fail, therefore, the space segment of the land remote sensing operational system could end when Landsat 5 becomes inoperable.

b. NASA is developing technology for advanced science investigations which will look at the surface of the Earth with new and improved capabilities, as well as supporting other planned endeavors in space and aeronautics. NASA also seeks ways to support the commercial uses of space by reducing technical and financial risks to U.S. Industry.

c. The Landsat program through 1984 has cost a total of approximately $800 million. Of this total, approximately $500 million was used for hardware development; $200 million was used for engineering support; and $100 million for applications research and/or user market. Throughout this period, there were other programs such as AGRISTARS, Application Pilot Tests, Technology Transfer, etc., that also utilized Landsat remote sensing data.

d. NASA's remote sensing program is designed to develop advanced technology to contribute to the needs of the entire nation. While the market place for remote sensing endeavors may not be large enough to support a commercial endeavor, the continued technology development nevertheless needs to be continued to keep the U.S. in a competitive position.

e. The State Department, Department of Commerce, and other elements of the executive branch of the government are the agencies that we believe have responsibility for following and assessing these developments. NASA, however, has not been involved in any such discussions with any of these government agencies.

QUESTION E-7:

The Land Remote Sensing Commercialization Act of 1984 (Public Law 98-365) gives NASA a mandate to conduct a vigorous R&D program in remote sensing.

a. How is NASA complying with its legal mandate to conduct a vigorous R&D program in remote sensing?

b. How is NASA supporting the commercialization of space remote sensing?

c. Why did NASA drop the multilinear array (MLA) program? With what was it replaced?

d. What remote sensing technology will NASA have ready to fly when the Landsat series ends?

e. What research is NASA doing on applications of land remote sensing?

ANSWER E-7:

a. NASA has commissioned the Earth Systems Sciences Committee (ESSC) to advise NASA on the pressing science issues and questions that lend themselves to study through remote sensing from space and to develop and recommend a plan to achieve this goal. This plan will be completed in early-1986 for our use in formulating a focused NASA program while communicating the views of the scientific community in this field. Concurrently and in consonance with the ESSC we have begun definition of integrated remote sensing systems that could capitalize on the capability offered by the Space Station. We have developed an initial report on the science requirements for such a system and are continuing to define system support requirements and the supporting infrastructure to produce a total geo-based information system.

Two major sensor technologies have been identified which will be required in the 1990's and we have a defined program to develop these technologies. The emphasis of this program has been and continues to be an effort to develop a capability to perform all-weather imaging of the land surface through active remote sensing with synthetic aperture radars, and to improve the passive sensors through the incorporation of solid state detectors.

Our active remote sensing developments achieved a highly successful flight in October, 1984, of the SIR-B instrument. This instrument has provided a set of data that will allow an evaluation of the L-band wavelength at multiple "look" angles. In the future we are planning a reflight of SIR-B to provide additional scene variety after which we plan to upgrade the system to include a C-band wavelength and refly it again.

In the case of passive remote sensing, NASA's approach has been to take an advanced step toward an imaging spectrometer that can provide narrow wavelength interval data from the visible into the infrared portion of the spectrum with approximately 128 channels. This decision required the elimination of the shuttle flight test program for a cryogen cooled linear array, but included continuation of the subsystem technology to a level of maturity to assure readiness for incorporation into a thematic mapper class instrument. Our flight hardware development activities are now focused on development of an imaging spectrometer.

b. NASA's overall Commercial Policy seeks to support commercialization of space including remote sensing through:

o Reducing the risks of doing business in space to levels competitive with conventional investments.

-- To reduce technical risks, NASA will conduct and stimulate additional research relevant to commercial developments in space.

-- To reduce financial risks, NASA will provide easy and inexpensive access to orbit as well as to experimental ground facilities.

-- To reduce institutional risks, NASA will help remove procedural impediments, offer organization support, and maintain consistent policies regarding its relationship with commercial space.

o Reaching out and establishing new links with the private sector to stimulate the development of private businesses in space.

-- NASA will expand its traditional links with the aerospace industry and academia to embrace other industries such as new high-technology entrepreneurial ventures and the financial and non-aerospace communities.

-- NASA will expand and target dissemination of scientific information to stimulate domestic space commerce projects.

-- NASA will use public announcements, interviews, speeches, press releases, and articles in technical and business journals to provide information about commercialization activities to industry, academia, and the American public.

c. NASA discontinued only the development and demonstration flight of a cryogen cooled instrument; MLA technology development activities are being continued.

The technology being used in the MLA instrument development was being overtaken by the capabilities of other remote sensing instruments such as the solid state planar array technology of the Imaging Spectrometer which NASA has also been pursuing. The MLA represents a technology that was originally intended to provide a transition between the Thematic Mapper and the next generation Landsat technology. As a result of the recent technological progress in sensors, together with revised projections of flight opportunities, it now appears appropriate to by-pass the MLA technology and concentrate our efforts on the Shuttle Imaging Spectrometer (SISEX) as the next major technology development in remote sensing.

d. As outlined in the answers to question (7. a.), NASA is pursuing the technologies necessary to provide an all weather active remote sensing capability with synthetic aperture radar and a passive electro-optical remote sensing capability with imaging spectrometers. In conjunction with these specific programs, we are defining several instruments based on these technologies which can be flown on the Space Station. Our current program plans are such that the requisite technologies (i.e., antennas, focal planes, coolers, and data handling systems), will be available in the early 1990's.

e. NASA has conducted scientific investigations of remote sensing data continuously since the early 1970's. Early on, these investigations were primarily designed to evaluate the types of information that could be inferred from the Landsat Multispectral Scanner Imagery. A variety of projects were conducted in conjunction with other government agencies to evaluate practical applications in crop forecasting, mineral exploration, water research management, etc. We are currently undertaking scientific investigations utilizing Landsat Thematic Mapper data. In response to a recent Announcement of Opportunity, over 190 proposals were received by NASA for Thematic Mapper investigations. We anticipate selecting approximately 30 of these during March/April 1985 to conduct meaningful research on the utilization of Thematic Mapper data to better understand composition, processes, and changes of the Earth's surface.

QUESTION E-8:

Please describe more fully what you intend to do in the Materials Processing program. The budget request is very general. In particular, please describe how you will divide work with the Office of Commercialization.

ANSWER E-8:

The request of $34M for the Microgravity Science and Applications Program will be used in the following way: approximately $12.4 million will be devoted to Research and Analysis (R&A) activities and $21.6 million for Material Equipment Operations. The R&A activities include ground-based research as well as support for Centers of Excellence. The Material Experiment Operations activity involves the fabrication of apparatus to be used in space as well as the funding for the Principal Investigators using specific apparatus for space experimentation. We are also developing a second generation piece of equipment known as the Advanced Automated Solidification Furnace which will allow for the development of certain types of detector materials such as mercury cadmium telluride and gallium arsenide.

Viewing the budget from a discipline standpoint, the FY 86 Material Processing funding is divided approximately as follows: Electronic materials, 20 percent; combustion science, 10 percent; fluid dynamics and transport phenomena, 15 percent; biotechnology, 22 percent; glasses, 13 percent; metals and alloys, 20 percent.

The Microgravity Science and Applications Division within the Office of Space Science and Applications is working very closely with the Office of Commercialization to encourage the commercial use of space. Specifically, we are engaged with industrial organizations both in joint technical research projects as well as in the implementation of Joint Endeavor Agreements and the fostering through technical interchange of additional Joint Endeavor Agreements. Specifically, the Office of Commercialization is the focal point for all potential space commercialization endeavors and provides the interface between industry and NASA for these activities. The Microgravity Science and Applications Division within the Office of Space Science and Applications provides the technical and scientific expertise for potential space commercialization of materials processing pursuits.

QUESTION E-9:

What is the status of the university centers for separation of biological materials established in response to our request in the FY 1984 authorization?

ANSWER E-9:

NASA prepared an announcement regarding the intent to establish one or more university centers for separation of biological materials. As a result of that announcement, six proposals from university groups were received. An ad hoc committee was established and reviewed these proposals for technical content, managerial capability, and potential for independent resource income. Following this fact finding, a selection of two Centers of Excellence was made by the Director, Microgravity Science and Applications Division within NASA. One of these Centers is located at the University of Arizona in Tucson, Arizona with Dr. Milan Bier as Director, and the other Center, which was established at the University City Science Center in Philadelphia, Pennsylvania, is acting as the leader of a consortium of 12 Universities in the Pennsylvania area. Dr. Paul Todd has been named as Director of this center. It should be noted that both Dr. Bier and Dr. Todd are recognized throughout the world as outstanding individuals in the field of biological research and separation techniques. NASA is delighted to be associated with these outstanding groups.

QUESTION E-10:

Materials processing shows an increase of $7 million.

a. Is this all new money or is there some reprogramming from other areas?

b. If there is reprogramming, what activities were brought in, from where, and at what funding level?

ANSWER E-10 a. and b:

The FY 1986 budget request included an increase of $7 million over the FY 1985 level for Materials Processing. This increase includes no reprogramming from other areas.

QUESTION E-11:

Your FY 1986 budget request shows no reduction of the FY 1985 Airborne Science program. We had been informed that $2.0 million of the FY 1985 funding was reprogrammed from this account into the Commercialization Office.

a. What is the situation regarding this reprogramming?

b. If the funds have been reprogrammed, what will be the impact?

c. Is this an example of the University Community being given a low priority in the budget?

ANSWER E-11:

As stated in NASA's letter to the Authorization and Appropriation Committees on December 27, 1984, $2.0 million from the Physics and Astronomy budget line item (suborbital) would be utilized as part of the funding required to establish an Office of Commercial Programs at NASA. The impact of this transfer will result in some reduction in total flight hours and some planned activities will be reduced or deferred; however, we do not believe these impacts will have a lasting effect on the science community nor do we believe this transfer indicates any lowering of the university community within NASA's overall priorities.

QUESTION E-12:

What fraction of the Life Sciences Flight Experiment budget line is for Spacelab experiments?

ANSWER E-12:

The entire Life Sciences flight experiments funding level is used to support Life Sciences Shuttle/Spacelab investigations. The primary thrust is concentrated on Spacelab module missions such as the Spacelab Life Sciences series which are dedicated discipline labs, and the so called "mini-lab" series including missions such as the International Microgravity Lab (IML) series; the German D-1 series, etc. Life Sciences participates in these mini-lab missions as a partner with international, commercial and other NASA payload users. A third payload type is a class of Mid-deck experiments. These payloads focus on University "Principal Investigator class" experiments in space medicine and space biology.

QUESTION E-13:

Your Life Sciences Budget Summary status on page RD 4-2 states that the Life Sciences Research and Analysis program includes five major elements one of which is "biospheric research." What does the "biospheric research" program do? What is its funding level? What is the difference between this work and the "Interdisciplinary Research and Development" program under Environmental Observations?

ANSWER E-13:

The Biospheric Research program explores the interaction between the biota and man's environment in order to develop an understanding of global bio-geochemical cycles. Laboratory and field investigations are correlated with remote sensing data to characterize the influences of biological processes on global life support systems. In FY 1985 and FY 1986, the Biospheric Research program funding level is approximately $1.7-1.8 million.

The Interdisciplinary Research Program under Environmental Observations seeks to bring together research efforts from a variety of disciplines, including life sciences, to study global processes. The two programs (Biospheric Research and Interdisciplinary Research) are mutually supportive in that they bring the expertise of many disciplines together to study the Earth as a system. The Life Sciences Biospheric Research program, however, pursues the interactions between the biota and the environment which are not directly applicable to the Interdisiplinary Research focus.

QUESTION E-14:

Please consider the Planetary/Mission Operations and Data Analysis program.

a. In particular, why is this program increasing so much?

b. Are there other large future increases in MO/DA built into the planetary missions now underway or planned? What are these increases?

ANSWER E-14:

The FY 1986 increase in the Planetary Mission Operations and Data Analysis funding over the FY 1985 level is required for the initial phase (approximately $22M) of the Galileo and Ulysses operations (both missions are scheduled for launch in May 1986) and for initiation of the Voyager Neptune encounter ($9M) activities. In addition, the FY 1986 budget request for this area includes the continued development of a Multi-mission operations and control center at the Jet Propulsion Laboratory which is consistent with the recommendations of the Solar System Exploration Committee (SSEC).

In FY 1987, the Planetary MO&DA funding requirement will increase over the FY 1986 level as a result of the annual operational requirements for the Galileo and Ulysses missions (increase of $35-40M over FY 1986). The MO&DA funding level should again increase in FY 1988/89 as a result of the launch and subsequent operational costs for the Venus Radar Mapper Mission.

QUESTION E-15:

Exactly how have the Voyager data on Jupiter and Saturn "revolutionized our concepts about the formation.... of the solar system"?

ANSWER E-15:

Voyager data from Jupiter and Saturn have provided information on the major planets which test the validity of theories that had been proposed. Some models predict a homogeneous composition for all of the major Planets; others predict cores of rocky and icy material of about the same size for each of the planets, but different sizes due to differing amounts of available gaseous material at the times of their formation. Relative densities within the retinue of satellites are also predicted by the models.

The Voyager data show that, while the two planets are primarily composed of hydrogen and helium, some substantial differences exist in their detailed composition. Their core sizes are different. The sources of their internal heat are very different, with Jupiter still radiating heat left over from its formation, and Saturn radiating heat due to helium precipitation in its interior. Although Jupiter's satellites show a regular decrease in density with distance from the planet, no such trend is apparent in the density of Saturn's satellites. The predominance of water ice in the rings and satellites of Saturn is also in sharp contrast with Jupiter's dusty ring and relatively dry inner satellites. Saturn's satellite Titan, with its massive nitrogen atmosphere, is also an enigma in the scheme of proposed formative processes.

The Voyager spacecraft have provided observations of a large number of previously unknown phenomena which were not predicted by existing theories and which bear heavily on the nature of the formative and evolutionary processes. The discovery of volcanism on Jupiter's satellite Io, a dusty ring around Jupiter, the extreme complexity of the Saturn Ring System, the evidence of geologically recent modification of the supposedly inert surfaces of Saturn's satellites, the details of magnetic field structure and characteristics of the associated radiation fields, multiple satellites in the same orbits, and an array of other Voyager discoveries all challenge the ingenuity of the theoriticians. It seems apparent that major modifications of existing theories are necessary if these newly discovered phenomena are to be explained.

QUESTION E-16:

What space science and applications missions are now being worked on at JPL?

ANSWER E-16:

Flight programs under development which are being managed by JPL for the Office of Space Science and Applications include the Extreme Ultraviolet Explorer (EUVE), Galileo, Ulysses, Venus Radar Mapper, and the Mars Observer. In addition, JPL is providing operational flight support for the Pioneer and Voyager missions.

QUESTION E-17:

The Comet Halley Investigation funding (in Planetary/Research and Analysis) was increased $500,000 in FY 1985 while (we are told) $2,000,000 was taken out of Halley aircraft observation program (in the Suborbital program). How do you explain this?

ANSWER E-17:

The Halley's Comet Watch and Experiments funding within Planetary Exploration Research and Analysis reflects a slight increase of $200,000 over the FY 1985 level which is basically an allowance for inflation. This funding supports the U.S. coordinated International Halley's Comet Watch and Giotto Co-Investigator program. The reduction in funds for the Suborbital program to establish the Office of Commercial Programs, resulted in a reduction of total flight hours and deferral of some planned activities in all of the science discipline areas. The effect of the reduction on the U.S. effort to study Comet Halley during its 1986 apparition is negligible.

QUESTION E-18:

a. Is the Infrared Telescope Facility in Hawaii fully funded in this budget?

b. If not, why not?

c. Are things going smoothly between NASA and NSF with regard to funding this facility?

ANSWER E-18

The operation of the Infrared Telescope Facility (IRTF) is fully supported by NASA's FY 1986 budget request. This support is in accord with provisions of a Memorandum of Agreement between NASA and the NSF. According to this agreement, NASA will provide long-term operational support for the IRTF (subject to periodic reexamination at intervals of approximately five years) while the NSF will support the development of instrumentation for the telescope. There have been no difficulties in providing support for the IRTF under the terms of this agreement. The arrangements between NASA and the NSF are working well.

QUESTION E-19:

What satellites are used to gather data used in the Geodynamics Program?

ANSWER E-19:

The Geodynamics Program uses positioning data and data on the Earth's gravity and magnetic fields to study crustal motion and deformation, earth rotational dynamics and the structure and composition of the Earth's interior.

The positioning data is acquired by Earth satellites including the Laser Geodynamics Satellite (Lageos-1) and the Beacon Explorer-3, launched by the U.S., and the Starlette Satellite launched by France. This program will also use the Experimental Geodetic Payload (EGP)to be launched by Japan in 1986 and the Italian-built Lageos-2 to be launched by the U.S. in 1987. Positioning data is also acquired by laser ranging to retroreflectors placed on the lunar surface by the U.S. and the USSR and by interferometric observations of astronomical radio sources. Earth gravity information is currently obtained from radio frequency and laser tracking of satellites at various altitudes and inclinations and from the analysis of altimetric data acquired with GEOS-3 and Seasat. Global magnetic field information has been obtained with instrumentation flown on the Orbiting Geophysical Observatories (OGO) and the Magnetic Field Satellite (Magsat).

QUESTION E-20:

A recent story in Science magazine ("Classification Dispute Stalls NOAA Program," p. 612 vol. 227, February 8, 1985) discusses how DOD is blocking civilian (i.e., NOAA) use of ocean data, including data from the Global Positioning System (GPS) to produce detailed maps of the seabed. DOD claims that the maps could be used by enemy submarines to find hiding places. On the other hand the technology for the mapping is available to other nations and to non-Federal researchers, so it will be available to the "enemy".

a. Are you familiar with this issue? If so, do you have a comment on it?

b. It appears that the data and maps could possibly be available to other nations, but not (directly) to U.S. civilian researchers. Does this make sense? Please comment.

c. Does this NROSS situation set a precedent of NROSS? Will NROSS data be available to the civilian community?

ANSWER E-20:

NASA is aware of this issue and has been in continuous contact with DOD regarding such issues. It is possible that DOD may determine it is in the interest of national security to make this information available to select foreign governments. However, we expect that this data would not be made available to private foreign researchers before it was made available to private U.S. researchers. As a result of discussions between NASA and DOD, we feel confident that N-ROSS Scatterometer and other data will be made available to the civilian U.S. community for research purposes.

QUESTION E-21:

There seems to be some overlap between the Upper Atmosphere Research and Analysis Program and the Atmospheric Dynamics and Radiation Research and Analysis Program. Please define them in such a way as to point out areas of overlap and areas of difference.

ANSWER E-21:

Both the Upper Atmosphere Research and Analysis and the Atmospheric Dynamics and Radiation programs are concerned with understanding the basic processes which control the Earth's atmosphere. These processes include the myriad of physical and chemical interactions which govern the exchange of energy and establish the structure and motions of the atmosphere.

Specifically, the Upper Atmospheric Research and Analysis program is a comprehensive research and technology effort designed to investigate and monitor the chemistry and physics of the atmosphere including both the stratosphere and mesosphere and the chemistry of the troposphere. Its primary goals are to provide concentration and distribution information about atmospheric ozone and other trace species, and to establish a basis for predicting the influence of natural and manmade phenomena on the ozone layer. It is not primarily concerned with the main dynamical circulations of the lower atmosphere which establish the basic weather and climate systems of importance at the earth's surface. The Atmospheric Dynamics and Radiation Program, on the other hand, is primarily concerned with those processes which influence the lower portion of the atmosphere (i.e. the troposphere). The objectives are to improve our understanding of atmospheric behavior on time scales ranging from minutes-to-hours over local-to-regional space scales (mesoscale processes), and on up to several weeks for the entire Earth (global scale processes). In addition, a major effort is concentrating on understanding the factors which control the Earth's climate and its predictability. In support of these objectives, a substantial effort is directed at developing improved and new remote sensing techniques for observing the atmosphere from space and in developing the numerical models for interpreting and exploiting the data. This program is concerned only with those aspects of the upper atmosphere which have a direct influence on the lower atmosphere, such as stratospheric aerosols, which affect the overall transfer of radiation throughout the atmosphere.

In summary, both programs, when combined, contribute to our overall knowledge of atmospheric physics and chemistry.

QUESTION E-22:

What is the ER-2 aircraft?

ANSWER E-22:

The ER-2 aircraft is an improved, more modern version of the U-2C aircraft.

QUESTION E-23:

Is NASA planning to use French SPOT data in its Oceanic Processes Research and Analysis program?

ANSWER E-23:

The Oceanic Processes Research and Analysis program presently has no plans to use French SPOT data as it is considered non-applicable to these efforts. However, NASA's Land Processes (Solid Earth Observations) Research and Analysis program is planning to use SPOT data on an as needed basis.

QUESTION E-24:

You refer to a Pilot Ocean Data System (PODS) as part of your Oceanic Processes program. Earlier you have mentioned GRIDS, a Global Resource Information and Data System.

a. What is PODS?

b. What is GRIS?

c. How are the two related?

ANSWER E-24:

The Pilot Ocean Data System (PODS), is a system designed to develop and demonstrate techniques for the efficient distribution and mangement of satellite-derived oceanographic data. The Global Resource Information System (GRIS) is a development concept of a system network to facilitate access to data sets necessary for the understanding and assesment of global scale resource questions, as well as to capabilities for processing and displaying these data for scientific purposes and for application in programs related to developing countries. The GRIS development concept would use NASA pilot data systems in the area of oceanographic data (PODS), as well as climate and land surface data, as starting points for an evolutionary system implementation. Thus, PODS would be one element of the embryonic GRIS; in time, GRIS would incorporate many such systems within its overall network.

QUESTION E-25:

In Space Physics R&A you are studying "how variations in the solar wind are coupled into the near planetary environment and neutral atmosphere."

a. What does this mean?

b. How do these variations in solar wind affect us on the Earth?

ANSWER E-25:

Key solar wind parameters include the solar wind velocity, the solar wind density and the solar wind magnetic field magnitude and direction. It is observed that changes in one or more of these parameters are correlated with the appearance of energized plasma, brightening of aurora, heating of the atmosphere and possibly changes in the weather system in the near-earth environment. Physical processes that may lead to this coupling between the solar wind and atmosphere are not yet understood and are still under investigation. The solar wind flow past the Earth's magnetosphere leads to a large electrical potential which can map into the upper atmosphere. The solar wind plasma also may enter directly into the magnetosphere. Both processes provide an energy input which is dissipated in the atmosphere. Models are now being developed, based on existing observations, which will be further tested and refined when the future International Solar Terrestrial Physics (ISTP) mission provides simultaneous observations in the four key regions of geospace.

QUESTION E-26:

The DOD is developing the Combined Chemical Release and Radiation Effects Satellite.

a. What is NASA's role? What is the NASA funding?

b. When is this satellite expected to launch?

ANSWER E-26:

a. The NASA role in support of the Chemical Release Radiation Effects Satellite (CRRES) is to manage the development of the CRRES satellite on a reimbursable basis for DOD, develop some chemical release science instrumentation, and launch the satellite with the Space Shuttle. The CRRES satellite is currently scheduled for launch in 1987. NASA is providing civil servant support to manage the CRRES development activities in addition to providing approximately $2M in FY 1985 and $3M in FY 1986.

QUESTION E-27:

What is the expected steady-state cost (in the NASA budget) of the SARSAT program?

ANSWER E-27:

The SARSAT program is currently estimated to have a steady-state cost to NASA of approximately $2M per year which supports a four-satellite (two NOAA and two Soviet) constellation; with NASA providing only system improvements and system engineering support.

QUESTION E-28:

What is the status of mobile communications activities?

a. What is happening in the private sector?

b. What is the FCC doing?

c. How are NASA's activities related to these other two?

d. How do you anticipate this area will develop?

e. Is there international involvement?

ANSWER E-28:

The private sector appears very interested in a mobile communications satellite and is in the process of preparing applications to the FCC and obtaining the financial backing required to establish and operate Mobile Satellite Service (MSS) in the U.S.

The FCC recently released an excellent Notice of Proposed Rulemaking (NPR) to allocate frequencies for MSS and solicit applications from industry to establish and operate an MSS in the U.S. The intent of the FCC is to license one of these competing firms within the next year.

NASA has provided the leadership over the last 5 years to identify MSS as a potential unique, multi-billion dollar business opportunity for U.S. industry. This has included petitioning the FCC to allocate the required commercial frequencies, and working closely with industry to identify critical technologies needed to accelerate the introduction of this new service in the U.S. The emerging U.S. industry is a direct result of NASA's efforts to date.

Assuming an FCC license to establish MSS is granted within the next year, we would expect a first-generation satellite system to be in operation by late 1988 or early 1989. This may be followed by a joint NASA/industry effort to develop the critical spacecraft and large, multiple-beam antenna technologies needed to implement second and third generation commercial systems. These developments could utilize the Space Shuttle and Space Station capabilities. If successful, the result would be a new, multi-billion dollar unique satellite industry with the U.S. in the leadership role.

Due to the technical nature of MSS and the very limited number of orbital slots available to North America, it is essential that the implementation of this new service be coordinated with our neighbors to the north and south. Toward this end, NASA signed an agreement with the Department of Communications in Canada to work together with NASA, the FCC, DOS, and industry in both countries to help coordinate the implementation of this new service. Similar discussions with Mexico are anticipated.

QUESTION E-29:

How much ACTS work is carried in the Communications/Research and Analysis program?

ANSWER E-29:

The ACTS program is fully funded under the ACTS item of the FY 1986 budget. ACTS is an advanced technology satellite development which will emphasize interconnectivity. When the ACTS program technology was being developed, we included only those technologies that absolutely needed to be tested in space. Most of our FY 1986 Research and Analysis funds are focused on the development of the accompanying interconnectivity technologies not requiring flight test.

QUESTION E-30:

a. How have you made use of SBIR set-aside funds in the Communications program?

b. Could other programs make similar use of such funds?

ANSWER E-30:

The SBIR program was designed to set aside R&D funds to encourage small business to participate in the NASA program. The intent is to provide "seed" money to companies to propose and develop innovative ideas. Ideally, these proposals, supported by the SBIR in a Phase I and Phase II award, would eventually result in marketable products or capabilities.

The set aside funding in SBIR is "pooled" in the SBIR Program Office. This office develops an annual SBIR Solicitation, based in part on the topics and sub-topics provided by NASA Centers and program offices. Small businesses respond to the solicitation, and based on the quality of the proposal, funding is allocated. There have been several SBIR awards in the Communications area, and these efforts have provided innovative research and ideas. However, the level of funding that may be allocated to any particular discipline in the SBIR program is not guaranteed. It is a function of the research areas in the solicitation, the response from the small business community, and the internal NASA review and award process.

The SBIR program is not limited to any one discipline area. Any program can participate in the process, but there is no guarantee that there will be responses to the solicitation, or that a particular proposal will withstand the rigor of the selection process and ultimately be funded.

QUESTION E-31:

Based on comments to the NASA Advisory Council we understand that you intend to reprogram FY 1985 funds into Interdisciplinary Research, yet your budget request does not indicate that.

a. Do you plan such reprogramming?

b. From where will the funds come?

c. What will you use the extra funds for?

ANSWER E-31:

No FY 1985 reprogramming actions are planned at this time to increase the Interdisciplinary Research activities. However, there is the probability that there will be good interdisciplinary-related tasks identified which total to more than the $1 million we currently have budgeted. If this occurs, related program areas will then be urged to consider including these tasks, as appropriate, within their programs. Therefore, those tasks related more specifically to activities within present on-going programs could complement those activities funded directly through the Interdisciplinary Research program.

Mr. NELSON. Thank you, Dr. Edelson.

There were some things that we wanted to get for the purpose of the record. First, with regard to the space telescope, your request includes $88 million for the space telescope mission operations.

In a report on the space telescope that the subcommittee prepared in the last Congress, we recommended that NASA "explicitly present its existing plans for operations, maintenance, and refurbishment" on the space telescope in a report accompanying the fiscal year 1986 budget request.

Now, our understanding is that you have not prepared this report. Is that correct?

Dr. EDELSON. That is correct, Mr. Chairman.

At this time, we have not completed preparation of this report. We anticipate doing so within the next few weeks, since the only remaining issue is the institutional assignment of the responsibility either to Goddard or the Marshall Space Flight Center and the attendant selection of a carrier for repair modules to be transported on the shuttle.

Mr. NELSON. If you have not been able to prepare the report, how do you know you will need $88 million in fiscal year 1986?

Dr. EDELSON. Well, although the report is not prepared as a finished, edited document, essentially all issues necessary to justify the $88 million have been decided.

Mr. NELSON. Well, exactly what will you spend the $88 million for?

Dr. EDELSON. The $88 million includes $57.3 million in telescope program operations and $30.7 million in maintenance and refurbishment.

The $57.3 million is divided as follows: $9.4 million, mission operations—that is, control center and other costs necessary to operate the telescope on-orbit, including prelaunch operations—$16.4 million for Space Telescope Science Institute operations; $11 million for continued development of supporting software; $6.5 million for science program implementation—that is, the guest observers and the like—$14 million for program support, IMS, contingencies, and other related costs.

The $30.7 million for maintenance and refurbishment includes $13.9 million for replacement science instruments and the replacement science instrument command and data handling system; $1.8 million for on-orbit spares; $4.8 million for systems engineering; $5.6 million for the development of support service equipment to be used on the orbiter; and $4.6 million for reserves and miscellaneous costs.

Of the above items, only a portion of the $5.6 million for support service equipment could be affected by the outcome of the maintenance and refurbishment study mentioned in the previous question.

Mr. NELSON. Dr. Edelson, when will there be scientific instruments built to replace the five that are going to be in the telescope at launch, and what will these cost?

Dr. EDELSON. The first scientific instrument being built to replace one of the initial five is a replacement for the WF/PC, the wide field/planetary camera, which is essentially a clone of the original. This will cost $33 million and will be available in early 1989.

Because of the criticality of this instrument to telescope operations, we have decided that an available replacement is a prudent investment. An announcement of opportunity soliciting proposals for the next replacement instruments was released last October and should result in replacement instruments in 1991.

Mr. NELSON. If we experience an active solar cycle after space telescope is launched, we may need to reboost it about once a year. Now, how do you plan to reboost it, and how high can the shuttle take the space telescope from a rendezvous at a low orbit? And what will it cost?

Dr. EDELSON. The initial reboost would use the STS system with the orbiter as the booster. After the orbital maneuvering vehicle has been developed, it would be used to raise the telescope to a yet higher altitude.

The shuttle should be able to take the Hubble space telescope to an altitude of 324 nautical miles. The cost will be anything from that of a full STS mission almost nothing if the reboost comes as part of a regular maintenance revisit.

Mr. NELSON. What are NASA's plans for preventive maintenance of space telescope to ensure continuity of science returns? Scheduled preventive maintenance could maximize the flow of the scientific returns.

Dr. EDELSON. NASA's plans for preventive maintenance for the space telescope begin with an exhaustive checkout on-orbit before the shuttle returns from the initial deployment. We will be prepared to make an initial rendezvous mission very shortly after deployment in the event of a catastrophic occurrence. The first scheduled maintenance mission will occur no earlier than 2½ years after launch, depending on the telescope's performance.

After approximately 5 years, the first scheduled instrument replacement should occur. We anticipate later maintenance activities being conducted in conjunction with the space station. These schedules are yet to be developed. We agree with your thought that preventive maintenance can maximize the flow of science returns.

Mr. **Nelson**. Is NASA giving enough attention to long-term plans for maintaining and repairing the five science instruments in the space telescope? These are the instruments that are not designed for repair on-orbit.

Dr. **Edelson**. You are correct, Mr. Chairman, in stating that the five science instruments are not designed for repair on-orbit. It is our intention, however, to charge out entire instruments with their replacements, which we believe is more cost effective than designing an on-orbit repair capability. This may be modified after the space station becomes operational, when additional repair facilities should become available.

Mr. **Nelson**. All right. Let's talk about a new subject, flight opportunities.

The science community has complained of a lack of opportunity for intermediate-size science payloads. An important aspect of this is the need to shorten the time between the initial idea for, and the flight of, such experiments.

So how can NASA find the best balance between a technically aggressive program and the need to support research programs with quick turnaround, inexpensive flight and mission opportunities?

Dr. **Edelson**. The best program can be developed by providing a close interaction between NASA Headquarters science managers and the research community. It is important that in program development an awareness be maintained of the importance of providing quick turnaround and inexpensive flight opportunities. We believe that our present interaction with the science community provides for this.

Mr. **Nelson**. Can NASA engineers be challenged to develop such opportunities?

Dr. **Edelson**. Yes. NASA engineers can be challenged to develop these low-cost flight opportunities.

Mr. **Nelson**. What is the responsibility of the science community; for example, should scientists assume more responsibility for intermediate science payloads? Should they restrain NASA from developing expensive missions? And how?

Dr. **Edelson**. Well, it is the responsibility of the science community to be aware of the necessity for these intermediate-class missions, and they should so tailor their advice to the agency to ensure that each discipline organization is aware of this requirement for a balanced program.

Mr. **Nelson**. Could NASA both better meet the flight needs of the scientific community and also maximize the utilization of shuttle flights by accommodating intermediate-class scientific carriers on a space-available basis?

Dr. **Edelson**. Yes. This would help significantly, and we are doing this at the present time.

Mr. **Nelson**. A recent report by the Shuttle Science Working Group recommended, among other things, first, a $25 million budget for developing intermediate-class payloads; number two, a program office for intermediate-size payloads; and, three, a shuttle science oversight committee. What is your response to each of these recommendations?

Dr. **Edelson**. Our response to this question is that we do not believe that a specific budget for any class of payloads should be separately identified. For the same reason, a program office for intermediate-size payloads we do not believe is warranted.

A shuttle science oversight committee may be desirable, but it should interact with other advisory committees rather than with NASA directly.

The logic behind these answers is that, while we agree on the necessity for intermediate-size payloads, we believe that they are the responsibility of the science discipline offices and that each office head should be charged with the concern for this legitimate interest.

We believe that management of the various payload categories without regard to the cohesiveness of a total scientific discipline would be self-defeating. We should be careful not to fractionate either our direction of programs or the advice we receive from the science community.

Thus, it is important that our advisers consolidate their recommendations and we not have a science discipline committee recommending large payloads, while a different committee suggests low cost, small payloads.

Mr. **Nelson**. One more question before I turn to Mr. Smith.

Should it be the responsibility of each discipline to ensure the health of its essential university research community by whatever means necessary, including intermediate-size missions?

Dr. **Edelson**. Well, I would not go so far as to say "by whatever means necessary." I would say that we need an understanding of the importance of intermediate-size missions as one segment of the advice expected from an advisory committee.

Mr. **Nelson**. Thank you, Dr. Edelson, for your answer to that question to build the record that we have wanted to build.

I turn to Mr. Smith.

Mr. **Smith**. I don't have any questions at this time, Mr. Chairman.

Mr. **Nelson**. Mr. Lujan, we are delighted to have you, our ex officio member, our ranking Republican member of the full committee. You grace us with the honor of your presence.

Mr. **Lujan**. Thank you very much, Mr. Chairman.

I do have a couple of questions, and they all relate basically to the Space Station.

I don't know if you have had a chance to review it, but the Banks Committee had a study that was given to NASA in the last few days that had particularly to do with the Space Station and how, from the scientific point of view—the mission and design and those kinds of things—how it would fit into what would be done from the scientist's point of view rather than the commercial point of view.

Have you had a chance to review that, Dr. Edelson?

Dr. **Edelson**. I have, Mr. Lujan. The Space Station Science Task Force under the chairmanship of Prof. Peter Banks of Stanford

University is actually a subcommittee of our Space and Earth Science Advisory Committee. We chartered that committee particularly to advise us and to serve as a focal point for the scientific community on the needs and opportunities to do science using the capabilities that the space station and its platforms would offer us.

We followed the preparation of this report through. I personally met with the Banks task force several times, attended their summer study at Stanford University last summer, and followed through on all of their recommendations.

We are very pleased with everything that the committee has done—the makeup of the committee, the way they have proceeded, and the results and the recommendations that they have made to us.

Mr. LUJAN. Does the design of the space station as we see it now, or the preliminary design or whatever one calls it, fit in pretty much with those things that were recommended, or do there have to be substantial changes?

Dr. EDELSON. It fits in pretty much, Mr. Lujan, although they have made some significant recommendations which we are pushing forward. The general configuration of the space station is just fine for science and applications, and we feel that there will be many ways that we can utilize it.

However, the recommendations of the Banks committee will be reflected in the activities of the phase B study contractors, and they will shape quantitatively what comes about.

For example, the space station capabilities that we intend to utilize primarily, at least in the initial operating capability, are the servicing and repair capability of the manned space station and the pressurized modules to do microgravity science and applications and life sciences mission, and the polar platform to do Earth observation.

Mr. LUJAN. Most of these things were taken into consideration at the very beginning?

Dr. EDELSON. Yes, they were, Mr. Lujan, but the Banks committee has made some specific recommendations about the nature and scope of the facilities at the service and repair facility, about the number and configuration of the pressurized modules, and the size, number, and instrumentation which would be carried on the polar platform, which will be very helpful in getting a handle on just how we will use the space station and its platforms.

Mr. LUJAN. And from the scientific to the commercial standpoint, I notice the heading of materials processing, just general, in the budget.

I am concerned—everywhere I go, I try to find out, you know, what kinds of things might we do in the space station from a commercial standpoint. What sorts of things are you looking at, other than the McDonnell Douglas experiment? Are there other things that might be in the planning for materials processing on the space station?

Dr. EDELSON. Yes, indeed, Mr. Lujan.

We have a healthy ongoing microgravity science and applications program which includes materials processing specifically, but it also includes other space processes.

We have stepped up that program, and you will see it reflected in the 1986 budget, from, I think, $27 million in 1985 up to $34 million in 1986—an increase of more than 25 percent—specifically to take advantage of the spacelab and other flight opportunities on the shuttle, and in turn as a staging and learning capability so that we can use the long stay time in orbit of the space station.

Mr. LUJAN. Do you have some specific targets of things—you know, the chips that we are doing, of course, is one specific target, and the electrophoresis—but some specific target as to metals of some kind and so on?

Dr. EDELSON. Yes, we do. I am going to ask Mr. Halpern, the director of our Microgravity Science and Applications Division, to speak on that in a minute, but we have divided our program into several areas including electronic materials and so on. We have goals in each area which include possible commercial applications, and we have in mind different facilities—furnaces and fluid physics modules and so on—that will match up with those.

Now, let me introduce Mr. Richard Halpern, who is director of that division, and perhaps he can add something to what I have just said.

Mr. HALPERN. Let me try to address the question specifically, Mr. Lujan.

In the area of electronic materials, about 2 weeks ago, I was at the Marshall Space Flight Center and approved a new project for a second-generation furnace which will allow us, we believe, to produce in small quantities but nevertheless demonstrate scientifically that mercury cadmium telluride which is a detector material, can be produced in the space environment with a purity that is impossible on the Earth.

During that same visit, I also authorized the beginning of a project in protein crystal growth, which is an area in pharmaceutical research, as you may know, that will allow us to understand the protein molecules and thereby initiate drugs that will take care of some of the problems that we are experiencing on Earth.

It certainly is not going to happen tomorrow, but the principal investigator, Dr. Bugg, anticipates the possibility of retarding, and perhaps even curing, such things as rheumatoid arthritis. He, has in fact, within the last, month demonstrated the molecular basis for blood-clotting materials. This kind of thing will continue and, hopefully, progress.

In the areas of metals, we are working toward understanding—a little mundane, but nevertheless—understanding the fluid dynamics of the processes, and we expect that we will be working in an area of immiscible alloys; that is, alloys which, in the Earth's gravitational field, separate out, but which are possible to be produced in the space environment.

I think I could go on and on and on, but there definitely are many things ahead of us.

Mr. LUJAN. Yes.

Mr. Chairman, in the interest of time, would it be possible to give the committee a rundown of those things with possible commercial uses? I will tell you why I am particularly interested. You know, we get so much criticism that we are putting up a space station; we don't know what we are doing; that it is all of these things. Those of us who are real supporters of the space station need to have some practical applications to say this is what we are going to do, and if we could have a listing with perhaps the possible commercial applications, that would be very helpful to us.

Dr. **Edelson**. I would be happy to provide that to the committee.

Incidentally, I have to say this in this regard. You may have noticed in Time magazine and Business Week and the Washington Post, a number of places, an ad about America's first factory in space that deals directly with this question. It is very, very interesting that we are seeing in this area quite a bit of commercial interest.

The amount of research work that we are doing together with industry has grown some five times what it was over the last year.

Mr. **Lujan**. Thank you, Mr. Chairman, and if that listing could be furnished to every member of at least the subcommittee, we would appreciate it.

Mr. **Halpern**. Sure.

[The information follows:]

The following activities, which are being planned by the Microgravity Science and Applications Division of the Office of Space Science and Applications for the Space Station, are expected to have a high commercial potential.

1. *Bioprocessing.*—Two areas are currently being pursued. These are separation techniques (e.g., electrophoresis) and protein crystal growth. The separation techniques will allow large production of pharmaceuticals, while protein crytallography will enable new pharmaceuticals to be designed. Long-range research leading to new drugs and biologicals to prevent blood clotting, arrest diabetes, aid in cancer diagnostics, assist in arthritis relief, and wipe out strands of influenza virus, is actively being supported.

2. *Electrical materials.*—Single crystals of great purity are being developed. Work is underway to produce mercury cadmium telluride for use as an infrared (IR) detector. Several programs, including a Joint Endeavor Agreement (JEA), are looking at production of gallium arsenide by different methods; gallium arsenide is a favorite successor to silicon for supercomputer design.

3. *Metals and alloys.*—Super alloys with very high-strength-to-weight ratios are being studied. Deep undercooling of metals, producing fine microstructures, has been demonstrated and will be continued.

Amorphous metals, also known as metallic glasses, are being investigated.

4. *Glasses and ceramics.*—Halide glasses, which may be subsequently pulled with fiber optics of unequalled purity, will be made using containerless processing. Used as transmission lines for communications, these fibers will allow up to 3 times the current distance of transmission without the use of repeater stations.

Ceramics which are hard but not brittle have long been a goal of engine makers, both for aircraft and automobiles. These can theoretically be produced in microgravity, and experiments to prove these theories are just getting underway. We are working with the major auto manufacturers in this activity.

Mr. **Nelson**. Mr. Monson.

Mr. **Monson**. Thank you very much, Mr. Chairman.

Being a new member of the committee, I am not totally aware of everything you deal in, but one thing that has received some attention in my State are the experiments that are produced by university students that have gone on space shuttle flights.

Could you help me understand better how these experiments relate to the work you specifically do and some of the aspects of how the costs of these are handled? I know that they receive some support from private industry, but is the support sufficient to cover the cost of these experiments going into space? Could you perhaps enlighten me on that subject?

Dr. **Edelson**. Yes, Mr. Monson, I think that you are referring to a special class of payloads that we fly on the shuttle known as "getaway specials."

Mr. **Monson**. Yes; I think so.

Dr. **Edelson**. These go into canisters—tubular, cylindrical canisters—in a preset package, which makes them easy to engineer and carry in the space shuttle. They are frequently referred to as "gas cans" for "getaway special canisters."

We have a student program and have advertised for student experiments and selected a number of these which have flown periodically. It is not a part of our science and applications program but a part of our student support program, although the scientists and engineers on our staff work with the students to develop and engineer their payloads.

Frequently, these are supported by industry, and for amounts of money which go from a few thousand dollars up to a few tens of thousands of dollars. Although we try to give a rapid response, it has been very popular and so we have a backlog of these.

They are done, incidentally, not only by university students but even by high school students. We have had some supported by foreign organizations and foreign countries.

It has been a very successful program, and it has, we believe, stimulated a great deal of interest in the study of science and engineering and technology in our high schools and universities.

Mr. **Monson**. Are the experiments suggested by you, or do they think up their own? What coordination is there between you and those entities that produce these experiments?

Dr. **Edelson**. We have advertised the opportunities, but the suggestions are made by the students themselves and, obviously, their own faculty members, and then we have a selection committee made by the National Association of High School Science Teachers. I may not have the name exactly correct.

They form a council to review all of the proposals and select and prioritize those that are most deserving, which we then schedule, manifest, and fly.

Mr. **Monson**. And what are the impacts on your budget of these experiments, or are they fully funded through outside sources?

Dr. **Edelson**. They are fully funded through outside sources. There is no effect on my budget at all. There is some funding that goes into it through the NASA-university educational program.

Mr. **Monson**. And what about the cost of carrying the experiment into space? Is that through your budget or through another budget?

Dr. **Edelson**. No; that is through the Office of Space Flight's budget, the space shuttle budget itself.

Mr. **Monson**. I appreciate your helping me to understand that better.

Dr. **Edelson**. Thank you, Mr. Monson.

Mr. **Monson**. Thank you, Mr. Chairman.

Mr. **Nelson**. Mr. Andrews, do you have any questions?

Mr. **Andrews**. I have no questions, Mr. Chairman.

Mr. **Nelson**. Mr. Mineta.

Mr. **Mineta**. Thank you very much, Mr. Chairman.

Dr. Edelson, unfortunately, I was not here earlier during your statement, but I do notice that on the top of page 23, you do make mention of the gravity probe-B, and I was surprised that it is not in your budget.

I would like to ask about your mentioning it here and saying that you will continue on aspects of the future GP-B, but it is not in your budget, and I was wondering what you intend to do on that.

Dr. **Edelson**. We had proposed, Mr. Mineta, to have a shuttle flight test of the engineering on gravity probe-B, a very exciting scientific experiment which will shed light and provide some level of proof to a special part of Einstein's relativity theory.

This was submitted to the OMB as part of the agency's submission, but it did not survive the review process, so the 1986 budget does not show funding for the GP-B shuttle test flight.

Mr. **Mineta**. So when you are saying that advanced research and technology development will continue on aspects of the future GP-B instrumentation, is there any part of what they are doing, both in terms of the project itself as well as in the management approach, that they are trying to include in this project? What is it of that whole project that you are going to be able to continue funding, given the fact that it was scratched out by OMB?

Dr. **Edelson**. We have carried research and development work, so called ATD, advanced technology development, for GP-B for a number of years, a very long period of time, I think as long as a decade.

Dr. **Rosendahl**. Two.

Dr. **Edelson**. Almost two decades.

Mr. **Mineta**. So that is really not a new start, then, is it?

Dr. **Edelson**. No.

Mr. **Mineta**. If you consider that you have been funding it that long?

Dr. **Edelson**. That is correct. We had hoped to increase this funding in the same budget category in order to enable a flight test.

Lacking that additional funding this year, we will continue at whatever level we can manage.

Mr. **Mineta**. Scratch around.

Dr. **Edelson**. Your words, not mine. [Laughter.]

We would like to continue the GP-B effort and keep it going.

Mr. **Mineta**. Well, given the importance of this, Dr. Edelson, has there been any lessening in the scientific community in interest in pursuing this project or the significance of the project?

Dr. **Edelson**. I would say there has been great interest, but I might ask Dr. Rosendahl, who has followed that very closely, to say a word about it.

Mr. **Rosendahl**. No, I don't believe that there has been any lessening of interest. As you know, a year ago we got a series of letters, including letters from five or six Nobel Prize winners, in support of that program, reaffirming its fundamental nature and the fact that it will test previously untested aspects of the theory of general relativity.

The National Academy of Sciences is currently conducting a physics survey—this is one of a series of annual reviews of all the fields of physics—that has been under the chairmanship of William

Brinkman, who was at Bell Labs at the time he did this study, who is now at the Sandia Corp.

There was a panel of that Physics Survey Committee, chaired by David Wilkinson of Princeton University, who looked at gravitational and cosmic physics as one of the major subfields of physics being addressed in this study.

It is my understanding, although the Physics Survey Committee report has not received final National Academy approval in its review process, but it is my understanding that the mission has in fact been very highly endorsed by the Physics Survey Committee.

So we do not detect any lessening of interest, as Dr. Edelson stated. I think that every time we look at it, every time we have discussions with the scientific community, there is no doubt that it is regarded as a very fundamental experiment.

Mr. MINETA. Dr. Edelson, was a large sum of money saved by removing GP-B from the NASA budget?

Dr. EDELSON. We had requested $12 million, Mr. Mineta.

Mr. MINETA. We need more than just some funds for apples to test that theory, don't we, it seems to me, in this instance?

Dr. EDELSON. Yes, indeed.

Mr. MINETA. Well, I think there still is a great deal of interest, and the value that comes of this GP-B, it seems to me, is just fantastic, especially when I think of it from another perspective, Mr. Chairman, of tying this in with the GPS, the global positioning satellite, and what they are doing on the gyroscope piece of it in testing this theory, and I just hope that we are going to be able to do something to ensure that the funding for GP-B is retained.

Thank you very much, Dr. Edelson.

Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Mineta.

Dr. Edelson, there is a long queue of science missions waiting to start development. Just the most mature prospects include TOPEX, ISTP, GP-B, AXAF, and SIRTF. All of these have been studied for some time.

With no new science starts in the budget for 1986, there is likely to be considerable anxiety in the science community as to the future of these missions. Now, how do you plan to set priorities for future missions?

Dr. EDELSON. We have, Mr. Chairman, an extensive planning process that we follow through each year and are in the middle of now.

We will carry over into consideration for fiscal year 1987 the new starts of TOPEX and ISTP, which we had hoped that we would get in 1986, and we will also consider two projects which were previously planned for candidate new starts in 1987. That will give us a list of four. They are TOPEX, the Ocean Topography Experiment; ISTP, the International Solar Terrestrial Physics Program; the CRAF, Comet Rendezvous Asteroid Flyby; and the AXAF, the X-ray Astrophysics Facility.

We will discuss, and have already discussed, these programs in great detail with our advisory committees, with the Space Science Board and their committees, and with our Space and Earth Science Advisory Committee, a committee of the NASA Council. We discussed the subject with them just yesterday during a SESAC meeting.

They will give us advice as to the relative importance of these and recommendations as to how they feel we should proceed toward a balanced program. The month of April will culminate in a series of meetings in which we will take all the advice and consideration and engineering studies that we have made on these programs and create a tentative 5- to 10-year plan, including a list a new-start priorities.

We will then subject that to the scrutiny and review and ask for recommendations by our various advisory committees to that. And, finally, we will go into the budgeting process during the summer with a list of priorities and a decision as to whether to request one, two, three, or four new starts in fiscal year 1987.

Mr. **Lujan**. Will the gentleman yield?

Mr. **Nelson**. Sure.

Mr. **Lujan**. I am concerned about those programs. We went ahead on the solar polar mission project, ISPM, and TOPEX, and got international partners, and now we are considering whether we are going to do it? Why did we go out and get the international partners, first of all? And now we are going to consider whether we are going to go forward with them?

Dr. **Edelson**. That is of very great concern to us, Mr. Lujan.

Mr. **Mineta**. He is right.

Dr. **Edelson**. You are referring to, I believe, the ISTP and TOPEX. The ISTP is an international program proposed for participation of Japan, Europe, through ESA, and the United States, through NASA. TOPEX is a joint mission with CNES, the French space agency.

In both cases, we made plans and have in fact agreements which are contingent upon program approval. We did discuss this very much with our partners, and they have a thorough understanding of the U.S. authorization and appropriation and budget process and understand the situation that we are in.

We immediately contacted our partners and in fact made a trip to Europe and talked with ESA and CNES about the considerations. So I think we all realize that whereas international cooperation is a wonderful arrangement—it gives us increased scientific and technical capability; there is cost-sharing involved; and it recognizes that the science itself is international—there is the disadvantage of being involved in multiple commitments and trying to move forward through several budgets at the same time.

Mr. **Lujan**. Thank you.

Mr. **Nelson**. I apologize to Mr. Slaughter and Mrs. Meyers. I did not see you all down there, and I will recognize you next.

I think the thrust of my question is, the Comet Rendezvous, if it were to be moved ahead in front of these more mature missions that we have spoken about, what would be the criteria for promoting it?

Dr. **Edelson**. Personally, Mr. Chairman, as I think you realize, I am in no position to play favorites among the programs. I am convinced, as one has to be, that every one of the missions is a vital and important program for one of the several disciplines that we have to support, although my own belief is perhaps necessary but certainly not sufficient. They are all supported very strongly by our advisory committees and by our own internal OSSA management group.

Now, with that preface, the comet rendezvous asteroid flyby mission is a very important, very high-priority mission. There is good science attached to it. It will be the first opportunity to explore the more primitive bodies, the comets and asteroids, which have great scientific interest. It is the first of a series of Mariner Mark II spacecraft that were strongly supported by the Solar System Exploration Committee.

In addition, there is one other aspect of that program in that it would be an in-house program at the Jet Propulsion Laboratory, and we are very eager to keep up the in-house competence and capability at JPL, which will suffer a loss of engineering once the Galileo program is completed.

All those things are strongly supportive of the high priority of a CRAF mission. On the other hand, as you point out, we are carrying over TOPEX and ISTP, which are indeed more mature, because they have already been through the process of being engineered with nonadvocate cost reviews and all the scrubbing and presentation that we have had before, and we have partners lined up and ready to go.

These considerations make the planning process very difficult. Since we are in the middle of the planning process right now, I cannot outguess it. But all of the points that I have just mentioned will be taken into consideration during our planning process.

Mr. **Nelson**. Mr. Slaughter.

Mr. **Slaughter**. No questions.

Mr. **Nelson**. Mrs. Meyers.

Mrs. **Meyers**. No questions.

Mr. **Nelson**. Well, thank you very much, Dr. Edelson.

Are there any further questions? Yes, Mr. Smith?

Mr. **Smith**. I missed it last time because I wasn't ready.

Dr. Edelson, I am a layman when it comes to these things, but it is very, very fascinating.

In looking in the area of mission operations and data analysis with the Pioneer and the Voyager and those areas, there is a substantial increase there in dollars with really, obviously, no new spacecraft. We are looking at, as you say, support operations for these spacecraft.

I support what you are doing. This is meant as a question, not as a criticism. When you use terms in your report here like "Pioneer 10 will soon enter the unexplored region," or "Voyager 2 will have a close encounter with the planet Neptune," et cetera, can you tell me a little bit about what we are finding, what we are doing up there, what we plan to do with the information that we are getting here, so that we can give some justification?

What are the support activities? What are we finding? What do we expect to find with these outer reaches, I guess you would call it? It is just fascinating, but if you could be a little more specific than what you have here, I would appreciate it. I know you don't have a lot of time.

Dr. **Edelson**. Let me ask Dr. Briggs, who is head of our Solar System Exploration Division, to answer that question.

Let me put it in perspective first. Both the Pioneers—and you mentioned Pioneer 10—are ongoing programs launched a long time ago and on their way out of what we know as the solar system.

It is expected to go through what we assume is a boundary called the heliopause. Dr. Briggs will say something about that in a minute.

We support the work and the continued team to monitor, survey, and analyze the data and review the science, mostly under our MO&DA line, our mission operations and data analysis budget line.

The Voyager mission has already passed and taken startling imagery and gathered science in its encounter with Jupiter and Saturn; will hit Uranus in 1986 and then Neptune in 1989.

We had added to our budget this year a sum of about $10 million specifically to handle that additional work in solar system exploration. So you see that fraction of the money going into our mission operations line for that.

I think that we can say that that is probably the most valuable money that we spend because of its great incremental leverage. We have already spent all the money to build the satellites, to launch them, to carry on their specified missions, and now we are talking about the opportunities for extended mission.

Dr. Briggs.

Dr. Briggs. To answer your very specific question, what do we expect to find at these objects with the Voyagers and the Pioneers, Uranus and the Neptune flyby, the answer is, we really don't know what we expect to find. We are here, with these particular missions, very much in the first reconnaissance exploratory phase.

The outermost depths of the solar system, the planets Uranus and Neptune and Pluto, are barely understood at all on the basis of ground-based observations. You are out at a distance now where we have almost no information, really, to work with.

So you can only discuss it, perhaps, a little bit by analogy of what we have discovered at Jupiter and Saturn, because Uranus and Neptune do belong to a family of giant outer planets. The outermost planets are quite different from Mars and Venus and the Earth and Mercury, which are small, rocky planets. These are giant gaseous planets, and they formed, presumably, 4.5 billion years ago under circumstances somewhat different than the situation in the inner solar system.

It was much colder out there, and when the planets formed, they accreted a much larger proportion of the gases and the ices which created the giant planets. They also formed around them miniature solar systems of their own. They each have a system of quite large moons which, if they were in the inner solar system, we would think of as small planets, but they are just the moons of the outer solar system planets.

So if you look at what we found at Jupiter and Saturn, looking at the planets themselves, we found objects which have a tremendous amount of difference from the inner solar system planets. They give off a lot of heat which is being radiated not as a matter of being reflected from the Sun, but heat which has been retained within them since they were formed. The heat balance of the planets is quite different from the inner planets.

We look at the circulations of them, and we find that they are entirely different from anything we see in the atmospheres of Mars or the Earth or Venus. To be truthful, we don't thoroughly understand them. Yet the circulations of the planets appear to be driven an awful lot by the internal heating that I just mentioned, rather than simply the heating from the Sun. So we are getting into a whole new arena.

When you look at Uranus, the next planet that we go by in January, you find a planet which is not even rotating anything like the other planets. The axis of its rotation is in the plane of its orbit around the Sun. The Earth's axis of rotation is more or less perpendicular to the plane of its rotation around the Sun. The North Pole is pointing up and the South Pole is pointing down.

Uranus is quite different. It is lying on its side, and its north pole is presently pointing at the Sun. That automatically means that the circulation regime we expect to see on Uranus will be totally different than any other we have ever come across. It is very hard to predict what it will be like, so we are in a discovery mode in this case.

We also know from a limited amount of ground-based data that Uranus has a ring system again quite different from that of Jupiter or Saturn, and it is again very difficult to predict what we will find out when we fly by it.

We do know that even for the Saturnian ring system, which we had some reasonable amount of information on from ground-based data, we found out many details of its dynamical behavior, quite unexpected before we encountered it.

So Uranus is pretty much an unknown. It has a whole system of moons which are, some of them, in orbits quite different from those of the other moons of the other planets.

So, in that respect, I can only say that we are looking at something just strictly in a discovery mode. It will be only by putting it together into a package, understanding all of the other planets, that we will be able to think of them as a family and then be able to relate them back to their formation and thereby perhaps begin to understand the solar system as a whole and even how the Earth fitted into it.

Mr. SMITH. Where you have the monitoring devices in place for these spacecraft and the spacecraft already up, is it the increased data that you are receiving, the analysis of that data, that causes the necessary dollar increase here that you are talking about, roughly $40 million in this particular area?

Dr. BRIGGS. I think you are looking at three different items in that area.

Mr. SMITH. We are.

Dr. BRIGGS. The Voyager mission is, in 1986, going by Uranus, and that is therefore a peak of activity. Thereafter, what you are seeing in the budget is the first year of funding for the Neptune portion of the mission. If you add that in, you find that the Voyager portion of the funding goes about $9 million or $10 million above what it otherwise would have been.

You are also looking, in that part of the budget, at the launch of Galileo and the operations that are attendant on that. I think there is $20 million of mission operations for the Galileo project in that.

Galileo is a very complicated spacecraft. Flying it is not going to be a trivial matter, and there is the option of exercising an Amphitrite, an asteroid observation sequence, in December 1986. That is going to call for a fair amount of resources.

There is another part of the budget contained in that area which shows an increase, and that is in the development of a multi-mission operations center at the Jet Propulsion Lab. This is looking into the future, looking into the period of the early 1990's when we will have the planetary observer spacecraft launched and the Mariner Mark II spacecraft that Dr. Edelson referred to.

We are putting together a much more efficient system of operating these spacecraft, where instead of each project having its own operation system, there will be a common operations system. This requires, however, some up-front money to develop it, and there is an increase in the funding in that program to develop that system. That is several million dollars; I forget the exact amount.

When you put those three items together—the Voyager activity at Uranus, the Galileo operations, and the buildup of the space flight operations center at JPL—that in total accounts for the difference in budget that you see.

Mr. **Smith**. What are you going to come and say to us if somebody sends one of those things back? [Laughter.]

Thank you, Mr. Chairman.

Mr. **Andrews** [as acting chairman]. Does anyone else on the panel have any questions?

[No response.]

Mr. **Andrews**. Thank you, gentlemen, very much.

Dr. **Edelson**. Thank you, sir.

Mr. **Andrews**. Our next witness is Dr. John Eddy, Senior Scientist, National Center for Atmospheric Research, from Boulder, CO.

Dr. Eddy, welcome to the committee. We all have before us your written statement. Please feel free, in your opening remarks, to read portions therein or make any comments you care to make before the questioning.

Mr. **Eddy**. Thank you.

STATEMENT OF DR. JOHN A. EDDY, SENIOR SCIENTIST, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH, ON BEHALF OF THE U.S. COMMITTEE FOR AN INTERNATIONAL GEOSPHERE/BIOSPHERE PROGRAM

Dr. **Eddy**. Mr. Chairman and members of the subcommittee, I was asked to appear today on behalf of the U.S. Committee for an International Geosphere/Biosphere Program, or IGBP, to give you a brief report on this activity.

My oral remarks, as suggested, will be taken from the slightly longer written document which you have.

Let me first explain what an IGBP is or might be, how it relates to the earlier NASA initiative called global habitability, and also give you a current report on the state of international progress in bringing such a program to reality.

The IGBP is a proposed program of international research aimed at understanding the Earth as a living planet. Of particular interest here are the interactions that are known to link the physical environment of the Earth, which we might call the geosphere, with those of the part that make our planet unique and, I would contend, the most interesting in the solar system, if not anyplace, and that is that it has life on it.

You can think of the IGBP as a program of global research much like the International Geophysical Year of 1957 and 1959, the IGY, though in this case with a sharper focus and a longer scale in time and, very importantly, the emphasis on understanding the linkages between physical processes and biological processes.

The program is as yet neither fully defined nor formally adopted at the international level, but it has been studied now for several years in this country, and it has been tested abroad with wide acceptance and enthusiasm. There is little doubt that such a program will be adopted, nor is there any real question what its ultimate goals will be.

I would like to speak about how it relates to global habitability and to other named programs that sound like this. The concept of an IGBP has grown in this country from initiatives taken in the National Research Council. The original spark for an international endeavor to study the Earth as a system came earlier, however, from NASA, where it was known as global habitability.

The National Research Council Committee on an IGBP has sought to give it a broader scientific foundation, and it is now under consideration as a formal international program by the International Council of Scientific Unions, or ICSU, where the program is known as global change.

Finally, a plan for national implementation is now being forged by a strong Earth Systems Sciences Committee, or ESSC, chaired by Dr. Bretherton, who made a statement to this committee in September.

If I could leave one thought with you today, it is that these multidisciplinary global programs with similar names and different origins are intellectually alike if not one and the same; and that they are all converging toward a common scientific program that has, I think, a tidal wave of support behind it, a program of fundamental science with profound societal implications for good; and we are ready to move; and NASA plays a key role in it.

During the past year, the U.S. Committee has been producing a plan for an international program that would apply new tools to understand the workings of the Earth as a coupled system. Our report was submitted only last month to the National Research Council, and it is now in the process of Academy review.

The central focus of the program we have considered would be to describe and understand the interactive physical, chemical, and biological processes that regulate the Earth's unique environment for life, the changes that are occurring, and the manner in which they are influenced by human actions.

An IGBP of this design is one of fundamental science, but it is eminently practical, for its underlying goal is to provide the bases for rational management of resources by the governments of the world and to improve the reliability of warnings of significant global change, including those of climate and hunger and regional drought.

We visualize the IGBP—that is, the U.S. Committee—as a well-defined program of research directed at providing the body of knowledge needed to assess the 100-year future of the Earth. Such a program would require more than a decade of effort. Planned now, it could begin in the 1990's, a significant period of projected change during which we can expect the first observable climatic impact of increasing carbon dioxide, the continued depletion of much of the tropical forests of the world, and increasing use of resources by an expanding world population.

It is important to note that such a program need not involve all of the organized research in the various fields that are involved. It need not, and should not, co-opt or deter other planned or ongoing studies, including other national and international initiatives in space.

In October of last year, the notion of a new international program of this sort was debated in the General Assembly of the International Council of Scientific Unions in Ottawa, following an all-day symposium on this subject.

Let me remind you that ICSU, founded in 1931, was the organizer of the IGY and a number of other global efforts such as the World Climate Research Program. It is the highest council of world science, and it is made up of representatives of the scientific research councils of 66 nations and the officers of 17 international scientific unions.

At the Ottawa General Assembly, a resolution was adopted that authorized ICSU to investigate a possible new multidisciplinary program directed at the global problems of a changing environment. An international advisory group was formed and charged with making a specific recommendation in 1986. That advisory group met 2 days ago here in Washington and, before that, in Paris.

Early meetings have made it clear that the United States will be looked to for leadership in both the framing and the implementation of an eventual program.

I think it likely that the ICSU advisory group will endorse a program much like the United States IGBP that I have just described. We can also expect that such a program will be adopted at the next General Assembly in 1986 for implementation in about 1990.

I need not add that the early and active involvement of NASA is essential to the success of any world program that will emerge. This requires the particular support of the Office of Space Science and Applications, because down-looking observations of the atmosphere, the oceans, and the solid earth are certain to be required.

The response of the U.S. Federal agencies, and particularly NASA, has been very helpful through these early stages. The National Research Council study is funded by NASA, NOAA, the Navy, DOI, and the DOE, and the participation of all of them will be a necessary part of the program, and they should all be involved in its design.

The IGBP is not a NASA Program, nor will it be a NASA show. The ESSC study, which I mentioned earlier, quickly recognized this and has been expanded to include the participation of all the Federal agencies involved in basic science.

What is needed now are prudent actions to ensure that the plans of NASA and other agencies in this area are compatible with what we know of the emerging international global change program. Many of the NASA down-looking, observing programs will fit naturally into the broader scope of the international program and add greatly to its strength.

The long lead-times involved in space-borne missions do not allow us to wait, however, for the deliberate steps of an organization such as ICSU before starting the needed NASA efforts, nor should we wait. If the United States is to lead, as it must, in a global change program, it must also lead in getting started now.

NASA has supported, on its own initiative, a set of missions which are certain to be central to an international program of global change. These include as ongoing missions the upper atmosphere research satellite, UARS, and the wind stress measuring scatterometer for the Navy Remote Ocean Sensing Satellite System, NROSS.

Now, as we look to new budgets, it is crucial to find ways to continue development of the oceanography missions TOPEX and the biologically important ocean color imager, OCI; the International Solar Terrestrial Program, ISTP; and the solid-earth Geopotential Research Mission.

I want to emphasize as an immediate action item, Mr. Chairman, that it is crucial that these four NASA programs be supported adequately in 1986 so that they can fly simultaneously with NROSS and UARS beginning in 1990.

This interdependent set of experiments, together with NASA's ongoing programs of research support in stratospheric and tropospheric chemistry, are the indispensable foundations of any IGBP. Another essential element is the development of the polar orbiting platform as a key element of the space station.

The ultimate success of an IGBP will depend on the health of the disciplines that go to work on it and the vitality of the U.S. programs in the earth and biological sciences that are in place when it starts.

The worst strategy possible would be to defer funding or initiation of well-studied programs such as the World Ocean Circulation Experiment and the International Solar-Terrestrial Physics Program while waiting for the start of a broader international multidisciplinary effort.

That concludes the oral part of my statement, but I am ready to answer any questions.

[The prepared statement of Dr. Eddy follows:]

STATEMENT OF

John A. Eddy

Chairman
U.S. Committee for an International Geosphere-Biosphere Program
National Research Council

BEFORE THE

Committee on Science and Technology
Subcommittee on Space Science and Applications
U. S. House of Representatives

Hearings on
FY 86 NASA BUDGET REQUEST

Tuesday, February 26, 1985
Room 2325
Rayburn House Office Building

Mr. Chairman:

I was asked to appear today on behalf of the U.S. Committee for an International Geosphere-Biosphere Program (IGBP) to give a brief report on the definition and progress of this impending and very exciting activity, both in this country and abroad. My statement follows presentations given by Dr. Thomas Malone and Dr. Francis Bretherton at hearings on an IGBP held on September 12 and 13 and by me a year ago, on February 9.

Let me first explain what an IGBP is and might be, how it relates to the earlier NASA initiative called Global Habitability, and the state of international progress in bringing such a program to reality.

The IGBP is a proposed program of international research aimed at understanding the Earth as a living planet. Of particular interest are those interactions that are known to link the physical environment of air and water and soil (the geosphere) with the plant and animal life of the biosphere. Our need to know those connections is both pressing and profound. Behind an IGBP is a widespread feeling in science that modern problems of climate, air and water quality and land use have reached the stage where understanding lies beyond the grasp of individual scientific disciplines. To understand these problems, and to predict the increasing perturbations of man, we need a new approach: one that involves a collaboration among different fields of science and that enlists the support of scientists around the world.

You can think of the IGBP as a program of global research much like the International Geophysical Year (IGY) of 1957-1959 -- though with a sharper focus and a longer scale in time, and, very importantly, an emphasis on understanding the linkages between physical processes and biological processes. It will entail new dimensions of measurement and involve recently emerging techniques of data management and dissemination and computerized modeling.

The program is as yet neither fully defined nor formally adopted at the international level, but it has been studied now for several years in this country and tested abroad, with wide acceptance and enthusiasm. There is now little doubt that such a program will be adopted. Nor is there any real question what its ultimate goals will be.

The concept of an IGBP has grown in this country from initiatives taken in the National Research Council, through initial efforts of Dr. Herbert Friedman. The original spark for an international endeavor to study the Earth as a system came earlier, from NASA, in Dr. Edelson's

Office of Space Science and applications, where it was known as Global Habitability. The National Research Council Committee on an IGBP has sought to give it a broader scientific foundation, and is now under consideration as a formal international program by the International Council of Scientific Unions (ICSU) where it is known as Global Change. Finally, a plan for national implementation is now being forged by a strong Earth System Sciences Committee (ESSC), chaired by Dr. Bretherton under auspices of the NASA Advisory Council.

If I could leave one thought with you today it is that these multidisciplinary global programs with similar names and different origins are intellectually alike if not one and the same. They are all converging toward a common scientific program that has a tidal wave of support behind it: a program of fundamental science with profound societal implications for good. We are ready to move, and NASA plays a key role.

These independent initiatives spring from a common awareness of the intricate web that supports life on our planet, a growing feeling that science, organized in disciplines, misses much of the fundamental connectedness of living and non-living parts, and a common perception that the need to know is urgent and that the tools are now at hand. These new tools include our ability to look at the Earth from above, a new arsenal of techniques to study its oceans and land and air and biota, and the power, through modern data handling, to share and manage the vast quantities of data that need be involved.

During the past year, the U.S. Committee has been producing a plan for an international program that would apply these tools to understand the workings of the Earth as a coupled system. It would require the participation of many nations and draw upon the efforts of many fields of science: of geology, oceanography, atmospheric physics and chemistry, biology, and solar-terrestrial studies. It would be made up of an array of planned, cooperative programs of observation, modeling, and process studies with opportunities for mutual discussion and interpretation. It would lean on spaceborne observations for global perspective, but the preponderance of needed measurements would need to be made on the ground and on the oceans, from within the habitat of life. It would be a focused program that builds selectively upon existing national and international initiatives in science, but with important new initiatives of its own. And it is a program which seems to us so clearly needed and compelling that it must be started now.

Our report was submitted last month to the National Research Council and is now in the process of Academy review. The central focus of the program we have considered would be:

> To describe and understand the interactive physical, chemical and biological processes that regulate the Earth's unique environment for life, the changes that are occurring in the system, and the manner in which they are influenced by human actions.

An IGBP of this design is one of fundamental science but it is eminently practical, for its underlying goal is to provide the bases for rational management of resources by the governments of the world, and to improve the reliability of warnings of significant global change -- including those of climate and hunger and regional drought.

The program we suggest would emphasize global studies in six areas:

1. Studies of lake sediments, ice cores and tree-rings to recover the record of past environmental change.
2. Investigations of the physical environment of the Earth, including the atmosphere and oceans, snow and ice fields, and the solar-terrestrial system.

3. Studies of global ecology and the interactions of biota with the physical environment of the Earth.

4. Studies of the cycling of chemicals important to life in the air, on land and water, and in living forms, including compounds such as carbon dioxide, methane, and other greenhouse gases.

5. Studies of the global cycling of water and the reservoirs such as ice-caps and underground aquifers.

6. Studies of the soil reserves of the Earth, their erosion and formation and the impact of intensive agriculture on the human carrying capacity of the planet.

We visualize the IGBP as a well-defined program of research directed at providing the body of knowledge needed to assess the 100-year future of the Earth. Such a program would require more than a decade of effort. Planned now, it could begin in the 1990's -- a significant period of projected change during which we can expect the first observable climatic impact of increasing CO_2, the continued depletion of much of the tropical forests of the world, and increasing use of resources by an expanded world population.

An IGBP of this design departs from the model of an IGY in two critical regards: it would be sharply focused on specific goals, and it would embrace biology as well as geophysics. The glue that ties the two together is biogeochemistry: the cycling of carbon and nitrogen and other essential elements between living and non-living realms. Much of our discussion has centered on those studies that involve significant interactions within the biosphere and that are most subject to human perturbation. Such a program need not involve all of the organized research in the various fields involved. It need not and should not co-opt or deter other planned or ongoing studies, including other national or international initiatives in space.

Why now?

Since their beginning, the efforts of the earth and biological sciences have been directed at the goal of understanding the Earth and life upon it. We work at assembling a jigsaw puzzle of countless pieces that must fit together to describe the whole. It is the way of science to divide and conquer through specialization. Some have been working on the sky, some on the water, and some on the landscape and the living creatures that are there. These efforts have accomplished much and must proceed. But we now sense ways that major parts may fit together, as join they must. Moreover, the time to put the puzzle together is fast upon us. I need not remind you of the real concerns of drought or of air and water quality or of dying forests and depleted soils. Or that these problems of the environment -- which can only multiply in years to come -- bring ever increasing demands for action and hence for more reliable information.

In spite of the need and desire to know how Nature will respond to perturbing human actions, we are obliged to admit that we cannot predict, reliably, either the occurrence or the consequences of such actions. We see two reasons for this. The first is that we lack an adequate understanding of the way in which the global system operates, and the interactions between component parts such as oceans and air and plants and earth. The second reason is that the impacts of human actions are inevitably mixed in a natural pattern of environmental change. In effect, the environmental scientist is asked, as in the case of CO_2 or chlorofluoromethanes, to read a manmade "signal" in an incompletely defined background of natural processes, and to forecast what the combined consequences will be. An IGBP would be directed at the roots of this dilemma, through a determined, global study of the physical, chemical, and biological processes that have produced and now maintain the environment needed for life on Earth.

In October of last year, the notion of a new international program of this sort was debated in the General Assembly of the International Council of Scientific Unions in Ottawa, following an all-day symposium on the subject of Global Change. ICSU, founded in 1931, was the organizer of the IGY and a number of other global efforts such as the World Climate Research Program. It is the highest council in world science and is made up of representatives of the scientific research councils of 66 nations and the officers of 17 international scientific unions. At the Ottawa General Assembly a resolution was adopted that authorized ICSU to investigate a possible, new multidisciplinary program directed at the global problems of a changing environment. An international advisory group was formed and charged with making a specific recommendation in 1986. Dr. Malone and I serve on that advisory group. Early meetings have made it clear that the U.S. will be looked to for leadership in both the framing and the implementation of an eventual program.

I think it likely that the ICSU Advisory Group will endorse a program much like the IGBP that I have just described. We can also expect that such a program will be adopted at the next General Assembly, in 1986, for implementation in about 1990.

I need not add that the early and active involvement of NASA is essential to the success of any world program that will emerge. This requires the particular support of the Office of Space Science and Applications, because downlooking observations of the atmosphere, oceans, and solid earth are certain to be required.

The response of U.S. Federal agencies, and particularly NASA, has been very helpful through these early stages. The U.S. National Research Council study is funded by NASA, NOAA, USN, DOI, and the DOE; the participation of all of them will be a necessary part of the program, and they should all be involved in its design. The IGBP is not a NASA program, nor will it be a NASA show. The ESSC study, mentioned earlier, quickly recognized this and has been expanded to include the participation of all of the Federal Agencies involved in basic science.

What is needed now are prudent actions to insure that the plans of NASA and other agencies in this area of research are compatible with what we know of the emerging International Global Change Program. Many of the NASA downlooking observing programs will fit naturally into the broader scope of the international program, and add greatly to the strength of the endeavor. The long lead times involved in spaceborne missions do not allow us to wait for the deliberate steps of ICSU before starting these NASA efforts. Nor should we wait. If the U.S. is to lead, as it must in a Global Change Program, it must also lead in getting started now.

NASA has supported, on its own initiative, a set of missions which are certain to be central to an international program of Global Change. These include as ongoing missions the Upper Atmosphere Research Satellite (UARS) and the wind-stress measuring scatterometer for the Navy Remote Ocean Sensing System (NROSS). Now, as we look to new budgets, it is crucial to find ways to continue development of the oceanography missions TOPEX (Ocean Topography Experiment) and the biologically-important Ocean Color Imager (OCI), the International Solar-Terrestrial Program (ISTP), and the solid-earth Geopotential Research Mission (GRM).

Mr. Chairman, with the prospect of no new NASA starts, I want to emphasize as an immediate action item that it is crucial that these four NASA programs be supported adequately in 1986 so that they can fly simultaneously with NROSS and UARS beginning in 1990. This interdependent set of experiments, together with NASA's ongoing programs of research support in stratospheric and tropospheric chemistry, are the indispensable foundations of any IGBP. Another essential element is the development of the Polar Orbiting Platform as a key element of the Space Station.

The ultimate success of an IGBP will depend on the health of the disciplines that go to work on it, and the vitality of U.S. programs in the earth and biological sciences that are in place when it starts. The worst strategy possible would be to defer funding or initiation of well-studied programs such as the World Ocean Circulation Experiment (WOCE) and the International Solar-Terrestrial Physics Program while waiting for the start of a broader international, multidisciplinary effort. The IGBP needs these as a base to build upon. The same is true for the general support of research in all of the fields involved. Today's programs of research in the earth and biological sciences are training the young scientists who will guide an eventual IGBP.

END

U.S. COMMITTEE FOR AN IGBP

John A. EDDY, National Center for Atmospheric Research, Chairman

D. James BAKER, Joint Oceanographic Institutions, Inc.

Wallace S. BROECKER, Lamont-Doherty Geological Observatory, Columbia University

Charles DRAKE, Dartmouth College

Peter EAGLESON, Massachusetts Institute of Technology

William S. FYFE, University of Western Ontario

W. Lawrence GATES, Oregon State University

John IMBRIE, Brown University

Robert LOOMIS, University of California at Davis

James McCARTHY, Harvard University

Michael McELROY, Harvard University

Mark F. MEIER, U.S. Geological Survey

Harold MOONEY, Stanford University

Andrew NAGY, University of Michigan

Ronald PRINN, Massachusetts Institute of Technology

S. Ichtiaque RASOOL, Jet Propulsion Laboratory, California Institute of Technology

Roger REVELLE, University of California, San Diego

Norman J. ROSENBERG, University of Nebraska-Lincoln

STAFF, National Research Council

Peter ABEL

Robert S. CHEN

John S. PERRY

Mr. **Andrews**. Thank you, Dr. Eddy.

You mentioned in your statement that you have reviewed the IGBP study. I wonder if you agree with the report in general, and if you have any specific comments you would like to make about that report.

Dr. **Eddy**. The study to which I believe you refer is the report of the U.S. Committee for an IGBP, and I chair that committee, so I am quite familiar with it. I certainly agree with it, therefore.

I think there are two significant things about the report, though. One is that it is written by a broad group of disciplinary scientists who find strong enthusiasm for it. We are not seeing here a disciplinary push within, say, astronomy or Earth sciences or biology, but a strong effort to work together.

The other important thing I can tell you is that the international community that has seen privileged copies of this draft report is also enthusiastic about it; that on Sunday of this week, in the Joseph Henry building, that group of scientists essentially endorsed the framework of that report. So I think we do know what it is going to be like.

Mr. **Andrews**. Thank you.

Mr. Smith.

Mr. **Smith**. No questions at this time.

Mr. **Andrews**. Mr. Monson.

Mr. **Monson**. I have no questions.

Mr. **Andrews**. Mr. Slaughter.

Mr. **Slaughter**. No questions.

Mr. **Andrews**. Mrs. Meyers.

Mrs. **Meyers**. As I understand what you are saying, then, this is a study that studies the physical environment of air and water and soil and also the way plant and animal life relate to it, and it calls upon a number of different agencies to cooperate in this study.

But you do foresee—I guess this is the question—you do foresee that there will be international cooperation in this at a later time?

Dr. **Eddy**. Yes. The program would not be possible without international collaboration. It is our view that it must be an international study.

Mrs. **Meyers**. Immediate, I mean now?

Dr. **Eddy**. Now, except we are asking that NASA, in its planning and its emphasis on programs, recognize that this program is gathering on the horizon and is about to take form, and it will depend deeply upon NASA for support of missions that look down on the Earth from above.

At the same time, it is not a space program. We are talking about looking at the Earth as a whole and how it works. Much of the science has to be done on the ground and on the oceans.

But, to clarify your question, we are thinking of an international program that I am telling you I think is inevitable, that will have a very strong NASA component.

Mrs. **Meyers**. Can I ask one more question, Mr. Chairman?

Mr. **Nelson** [resuming as chairman]. Oh, absolutely.

Mrs. **Meyers**. As a new member of this committee, I would like you to ask if you could explain to me what the ocean color imager is.

Dr. **Eddy**. The Ocean Color Imager is one of an array of satellites that has been under study by NASA for some time to do essentially remote sensing of the ocean, to look down on the oceans from above, for the purpose of understanding the biological productivity of the ocean.

It looks at the ocean in different wavelengths to try to tell us something about the kind of life that exists there. I am not talking so much about the whales and the dolphins that swim there as the minor forms of life that start the initial chain, the food chain, that allows us all to live on the planet.

Involved in those questions are some very intriguing ones of the sort that ocean life, the simplest forms that live near the surface, are probably deeply involved in climatic change, in that they are involved in the production of carbon dioxide, which is quite a lever on climate, and that it is in these sorts of connections that a program like an IGBP or global change attempts to answer questions.

The emphasis on the ocean color imager is that it gives us a way of looking with great power on the biological life of the ocean. That is a brief statement of it.

Mrs. **Meyers**. Thank you, Dr. Eddy.

Dr. **Eddy**. Remember again that we are talking about looking at the Earth as a planet, and I guess the plea of this program, which has strong support, it says, Yes, the other planets are interesting, and there are a lot of them out there—and as an astronomer, it has been my life to look at them—but we are saying it is time we took a really good look at the most interesting of all the planets and the one that is the most practical for us.

Mr. **Nelson**. Mr. Mineta.

Mr. **Mineta**. Mr. Chairman, just one quick question. Another hat I wear around here is chairing the Aviation Subcommittee for the House Public Works and Transportation Committee.

One of the things I have been interested in that NCAR has been doing—and a great job—is that dealing with wind shear. Now, given the fact that your interests are a little higher up in the atmosphere, do you know how things are going with the wind shear project?

Dr. **Eddy**. Mr. Mineta, I think I can answer that in part, although I am answering it now as a member of NCAR. It is just an accident that I am there for this program, because it is quite a bit broader than atmospheric science.

But the wind shear program, I think, has been a terribly successful one and a beautiful example of how, if you can just get basic researchers to begin to look at practical problems, they can come up with some answers that are terribly important. The business about wind shear around airports and downdrafts and that study, I think, has been kind of a jewel in the crown of things that get done in the atmospheric sciences.

I cannot tell you more than that, except you are right in recognizing that that study was done at NCAR and that it has been a very profitable one.

The connection with the program I am talking about, I suspect, is only slight, other than the fact that the atmosphere and the motions in it are such a necessary part of climate and the operation of the Earth as a system.

Mr. MINETA. Has there been a cutback in the funding in either your part of the program—or let me start first with the wind shear part of it. Has there been any kind of significant reduction there that you are aware of?

Dr. EDDY. Since I am not that close to that operation, I cannot answer.

Mr. MINETA. I understand, fine. What about in your area?

Dr. EDDY. In the area of climate research—and I do solar research—I think there has been a heartening expression of interest in the kind of funding that we get, and I think, as much as the funding, I am terribly encouraged by the interest in this committee in this kind of program.

Under your previous chairman, Mr. Volkmer, we really were encouraged to go ahead. There was a synergism, I think, where your interest made us feel stronger in what we are doing in science.

I think I am skirting a bit your questions about funding in hemispheric science and solar physics because, for this appearance, I think perhaps they are not as relevant.

Mr. MINETA. I take it from the increased interest—and there must have been a little—at least you were able to hold your own, dollarwise.

Dr. EDDY. Yes.

Mr. MINETA. Thank you very much, Doctor.

Thank you, Mr. Chairman.

Mr. NELSON. Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

What is your single biggest concern about the budget as submitted by President Reagan?

Dr. EDDY. Well, the single biggest concern is the lack of new starts in the Earth science and applications programs and in what your chairman, Mr. Nelson, I thought rather eloquently referred to as the bow-wave of programs that are going to be continually pushed forward in the budget every year.

There are two concerns there. One is that this program of international effort, where the United States has played a strong role and will, is going to need these sorts of basic look-at-the-Earth-from-above programs.

Another concern which I mentioned last year when I was here was the one I heard Mr. Lujan mention a moment ago; that is, the fact that we are fast becoming known as a nation in space that makes commitments and promises to other nations, and then we tend to kind of fall back on them a bit, in the case of the solar polar program. It is a concern we have now about the ISTP, a strong concern about TOPEX.

Mr. WALKER. I would assume from that answer, then, that you believe that new starts, regular new starts, are a crucial part of maintaining scientific momentum in space applications. Is that correct?

Dr. EDDY. Indeed, I do, tempered by the realization that it is very hard to make decisions about what you can buy and what you cannot buy and that budgets are very hard to bring about.

Mr. WALKER. That brings me to my next question. Given the crucial nature of new starts, are there areas that we as a subcommittee ought to be looking at to possibly revise the President's budget so that we could include some new starts but yet maintain the kind of budget ceiling that the President has suggested?

Dr. EDDY. Mr. Walker, in my testimony I have listed a number of programs that I thought were not only essential to this program but essential to understanding the Earth as a planet. It seems to me those starts, like the ocean studies and so forth—and that is maybe what you are asking me; that is, what would I cut out to do that.

Mr. WALKER. Yes, that is the point. I think that you did give us a pretty good rundown in your testimony of some of the kinds of things that we might consider for new starts and some of the kinds of things that are vital.

The question we have in dealing with the budgetary situation that is before us is, what do we change in that budget in terms of eliminating or cutting back so that we find the funding to begin these crucial new starts?

Dr. EDDY. Of course. I think I prefer to answer that only in general, that I would hope that the needs of looking down on the Earth from above would be kept right up front, since that has got to be one of the most practical returns from space, and that those have to be tempered against the really exciting explorations of the outer solar system or of other planets of the galaxy; that we may be seeing here a program that has all the scientific interest of those but also an urgency that I think is real about understanding the Earth and some of the complicated problems that are on it that seem to be beyond the realm of science as traditionally defined.

I am going back to generalities again, but I am saying that to ask for some sort of balance between looking at downlooking programs that look at the Earth compared to looking at other planets and other stars.

Mr. WALKER. So if you were to be given a choice of priorities from your vantage point, you would say that the more crucial priority is to have the sensing devices for Earth applications rather than the deep-space activities.

Dr. EDDY. Certainly for this program, that is a priority.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Volkmer.

Mr. VOLKMER. Thank you very much, Mr. Chairman.

I would like to continue with the comments of the gentleman from Pennsylvania because I think they really hit the point.

I would like to ask first, though, Dr. Eddy, when the gentleman from Texas asked you about a draft report, as you remember, last year we held hearings on this very same subject matter, and we have a draft report on those hearings by this committee, and I believe you have had an opportunity to look at that draft report.

Dr. EDDY. Yes, I have.

Mr. VOLKMER. Do you see anything objectionable in that that you can find?

Dr. EDDY. No, I do not. I was very encouraged by it.

Mr. VOLKMER. Do you generally agree with the report, then?

Dr. EDDY. Yes, I do.

Mr. VOLKMER. All right. I would like to know, too—you mentioned NASA. We know that NASA has to be involved if we have an IGBP, but also, we are going to have to have cooperation from other agencies as well as NOAA, DOE, and all the rest of them, NSF and others.

Dr. EDDY. Of course.

Mr. VOLKMER. Have you had any communications with them on the idea?

Dr. EDDY. Yes, indeed, we have, Mr. Volkmer. They were involved in the early studies of 2 years ago. They helped fund our present study. But the biggest connection, I think, now comes through this Earth Systems Sciences Committee that Dr. Bretherton heads, who reported to your committee last autumn.

Mr. VOLKMER. Right.

Dr. EDDY. That committee was originally set up by the NASA Advisory Council, but it soon become apparent to them that they had to have the active involvement of agencies like NSF and NOAA, and so they are doing that now. I think that is a terribly encouraging thing, that they are looking at the practical problems of interagency programs there.

It is certainly true that the other agencies are needed, and that is why I said in my statement that this is not to be thought of as a NASA program. That is one of the things that makes it so different, I think, from the original global habitability concept.

Mr. VOLKMER. It appears from your testimony here that there is, I would say, a strong probability that we will have an IGBP. Would you assess that as correct?

Dr. EDDY. Yes.

Mr. VOLKMER. We cannot say it is there, but we can say there is a strong probability.

Dr. EDDY. Yes, that is correct.

Mr. VOLKMER. If that would come about—and let's say by 1988 we had this international agreement to do these studies; however, in the meantime, we have not done anything as far as TOPEX—we have UARS on line, but we have not had anything, let's say, on TOPEX or any other ocean or terrestrial type of imaging satellites up there—how would that affect the whole IGBP?

Dr. EDDY. It would be a very severe blow to it. It would mean that the IGBP not only would have to wait for those, which doesn't seem so bad—we waited a long time to study the Earth as a system—but the more important thing is the collaboration, the cooperation of these spacecraft efforts, the fact that they are pieces of a joint study.

If we could have UARS up at the same time that we are looking down at the oceans, you would get a very powerful grip on atmosphere-ocean problems. If you could have the ocean color imager up there at the same time, you would get this overall view. So it is the need of having them up there together that drives it.

Mr. VOLKMER. Let's assume, let us say, that we were not able to fund everything that we would like to have this year, but let's assume that we were able to give and initially fund one or two. I know they are all important, but would you estimate that TOPEX would probably be top priority, or which ones would you put as your top priority?

Maybe I should first ask this: On the ISTP, we are in difficulty with that, anyway, are we not? As I understand it, we have pretty well backed off of that—not you, but NASA and the Government have pretty well backed off. Is that correct?

Dr. **Eddy**. It certainly is true, and you heard that in the earlier testimony, I think, this morning, some comments about that.

Mr. **Volkmer**. Right.

Dr. **Eddy**. For that reason—and it is a hard question you ask me—but I think TOPEX would have to be the first priority for this program. It is closer to the Earth, the living sphere idea. We sacrifice something if we don't have the solar terrestrial side of it going, also. But given the difficulties that it is encountering, particularly, then it is the ocean emphasis that seems to come to the front now.

Mr. **Volkmer**. All right. That helps me out quite a bit.

Now, the last thing I would like for you to discuss, Mr. Chairman, if you will permit me, is that, assuming that by 1990, 1991, somewhere in that time frame, we have both the imaging satellites in orbit and we have the IGBP going on, we have a lot of data all of a sudden coming in.

Dr. **Eddy**. Yes.

Mr. **Volkmer**. How are we going to handle that data, and who is going to fund the handling of that data? Do you have any ideas on that?

Dr. **Eddy**. Only that we totally agree that it is a very big problem that must be planned for and met in advance.

Dr. Bretherton, on the Earth Systems Science Committee, keeps pointing out that if this goes—and he is firmly behind it—we are talking about transmitting 10 to the power of 13 bits of data per day to the Earth from these observing programs. It is a tremendous amount of data. It means we have to be ready for it.

Part of the planning for this program, both within our country and internationally, is to think about this challenge. It is much more than a matter just of how do you handle a big chunk of data. To make it useful, these data have to be disseminated to users all over the world.

Indeed, that is one of the two reasons why we think such a program of the sort I am talking about can be mounted, that we now have the capability of almost instant dissemination of information and data, unlike the IGY, where we had to mail pieces of paper like this off to Nigeria or wait for it from them so we could put together a total picture. We can now transmit it instantly and have it instantly shared. We are talking about very large pieces of it.

There is no one I know, though, Mr. Volkmer, who feels that that is not possible or that we are talking about something that will require a tremendous increase in funding for data handling. It seems consistent with the sorts of things that are built into the present space program. I am optimistic enough to think that the technology of data handling and computers will continue to advance at the rapid rate that it has over the last years, and it will be possible.

But it is a concern; I can assure you that. I can also tell you that, as scientists, we are not asking for dollars for something that we don't think can be managed with data bits.

Mr. **Volkmer**. I recognize the fact that I am sure that we will have the technology and the ability to handle the data. The question is the funding of it in the future, too, that we have to look to that.

Let me ask you this. What you are discussing here today on the IGBP and the possible use of these satellites, we would be able to obtain the information about the Earth itself that we presently do not have or are not able to put together. Is that correct?

Dr. EDDY. That is correct.

Mr. VOLKMER. To me, this is just as equally important as—and I am not opposing, and in fact I am strongly in support of it—such things as Space Telescope. You take the Space Telescope, and it is going to be imaging outwardly to the unknown there, and it has huge costs. The total costs that I see of your program are very small in comparison to even those programs where we are looking at. I see nothing wrong; we need to do both.

Dr. EDDY. Yes.

Mr. VOLKMER. So, hopefully, we can find some funds—I am addressing Mr. Walker and his cooperation that we can find some ways to make some adjustments within this budget that came down from Pennsylvania Avenue to continue on these science parts. I am all in support of a space station—I will get on a soapbox—I am all in support of a space station, but I will be danged if I am going to see a space station knock out scientific experiments that we need. I think that we can find room for both.

Thank you, Mr. Chairman.

Mr. NELSON. All right. Thank you, Mr. Volkmer.

Dr. Eddy, could the polar platform component of the space station contribute to IGBP, and how could it?

Dr. EDDY. It is a very good question that you ask, and the answer is a resounding yes.

Mr. NELSON. In what way?

Dr. EDDY. Recall here that what we are talking about is looking down on the Earth from the vantage point of space in many ways, looking at the living parts, the nonliving parts, the atmosphere, not just taking pictures but trying to understand them.

The polar orbiting platform, as I understand that concept, would provide this sort of flexible, adjustable platform that would let us make these observations. It is the ideal sort of observing platform for it.

I think it cannot do all of it, but it is a terribly important part. I think the real tragedy would be that if the space station were done without that sort of general science platform built into it, and here is a case where you have both a very practical need, I would contend, more practical than manufacturing things in space, looking down on the Earth, a very practical and also now a very timely argument for that platform.

Mr. NELSON. Dr. Eddy, how about the NOAA weather satellites? Can they contribute to IGBP?

Dr. EDDY. One of the components of an IGBP that my U.S. committee is now drafting—and also realize that report has not been approved, and therefore I have to be very careful about saying lots about it—but one of the components of it certainly is to look at the Earth's climate, both in the past and in the present.

The NOAA satellites that monitor weather have been an essential part of our understanding the lower atmosphere all along. And so, yes, they are definitely a part of it, and a low-cost part of it.

Our concern among some of the people on my committee is what will happen to programs like this with the continued commercialization of such spacecraft, and here, besides an initial knee-jerk reaction against it, is the thought that, well, if we can just keep the data flow going, then that would help it. If that can be done through a commercialized device, such a program would proceed. I think it would proceed with more difficulty that way.

Mr. NELSON. What do you think we in the Congress should do about IGBP?

Dr. EDDY. I appreciate the question, Mr. Chairman.

I think the first thing is what you have done so well, and that is to keep aware of it. Whether you realize it or not, as I mentioned earlier, you have given us great encouragement with this interest.

The next point is to protect the parts of the NASA budget that look down at this most important planet. If efforts could be made to help bring back in the budget important programs such as TOPEX, that would be a tremendous step forward.

Mr. NELSON. Do you get concerned when we start looking at a future Landsat system, that we may not have an American Landsat in the future?

Dr. EDDY. Indeed, Mr. Chairman, I do. I find that so hard to imagine, that the country that was really first in space technically, that has always been best in space, that has been a leader in the world of science, that has been a leader in all programs of international cooperation in science, would fall back and not continue this most important aspect, most important use of space.

So, indeed, I am concerned if we give up to the French or to whomever the observations of the Earth from space.

Mr. NELSON. Do you think we are approaching it in a viable way in now negotiating with the proposal on a follow-on Landsat with private industry where there would be a subsidy from the Federal Government, or do you think that it ought to be entirely Federal Government?

Dr. EDDY. My main concern is that there be a continuous data flow, however it is done. I think that overrides the initial feeling of scientific conservatism on my part that, Oh, no, we cannot sell this thing down the river at such an early age as Landsat.

I could remind you there that I think the capabilities of Landsat and such techniques as looking down at the solid Earth and the liquid Earth from above have barely been scratched. I am sure you are aware of that. We are only beginning to do that.

A program of looking at the Earth as a whole is going to go much deeper into that, and we are going to find terribly important rewards from that. I just hope that we don't constrain what we see or how we can see it by these moves in terms of short-term budget saving.

Mr. NELSON. Let me ask you a technical question. From what you know of the proposal that is presently being negotiated on a follow-on Landsat, in your opinion, does that give you the technical kind of data that would satisfy your yearning for this future information, as opposed to the Government going out and building a straight Landsat follow-on?

Dr. EDDY. Mr. Chairman, the truth is that I am not that close to the details of the proposed arrangement, so I think I would be speaking beyond my knowledge to say anything very specific about it.

Mr. NELSON. All right, let me define it for you, then. The negotiations presently going on are that it include a thematic mapper, but it would omit the multispectral scanner.

Dr. EDDY. Oh, I see.

Mr. NELSON. Now, what do you feel about that?

Dr. EDDY. That would be a shock, because we need the multispectral scanner to do a lot of the biological studies of the surface of the earth, to distinguish one form of plant from another, to interpret some pretty basic things, like the growth of drought in Africa and other places. It depends heavily on—the only tool we have is the separation by wavelengths. So that would bother me some if we tried to get along without that.

Mr. NELSON. I would appreciate any further information you might want to send us on that subject.

Dr. EDDY. I shall do that.

Mr. NELSON. Are there any other questions from the committee members?

[No response.]

Mr. NELSON. We will adjourn, and we will reconvene at 2 p.m.

[Whereupon, at 11:27 a.m., the subcommittee recessed, to reconvene at 2 p.m., the same day.]

1986 NASA AUTHORIZATION

TUESDAY, FEBRUARY 26, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met, pursuant to call, at 2:10 p.m., in room 2325 Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. Nelson. The committee will come to order.

This afternoon we continue our hearings of this morning on the space science and applications with two distinguished panels of outside witnesses. We had to reschedule this hearing. It was originally set for tomorrow, and there was suddenly, beyond our control, business that was instituted by the House of Representatives tomorrow, so we had to rearrange this hearing, and on short notice I want to thank all of you for rearranging your schedules to be here.

Our first panel will deal with space science. Dr. Thomas Donahue, professor of physics at the University of Michigan, is chairman of the Space Science Board of the National Academy of Sciences; Dr. Louis Lanzerotti of Bell Labs is chairman of the Space and Earth Sciences Advisory Committee, part of the NASA Advisory Council; and Dr. Arthur Davidsen, professor of physics at Johns Hopkins, is here representing the Space Science Working Group.

We have several issues to discuss with this panel, but perhaps the most difficult is the lack of any new starts in this year's budget request. Given the situation with the budget, it is probably just not realistic to expect that the Congress is going to be adding a whole bunch of new starts, especially since NASA's budget request is one that fares out better as compared to other agencies of Government.

As a matter of fact, I think the only other two parts of the budget that have fared beyond NASA are the Defense Department and interest on the national debt. So, unless these witnesses today can tell us where to find the money, we are going to have some tight constraints as we look at this budget.

The question then becomes, what do we do now in anticipation of a crunch that will likely occur when the missions we expected to start this year get bumped into other missions in the production pipeline? It is no secret that ISTP and TOPEX and possibly the shuttle test of gravity probe B were ready to start this year and that AXAF and SIRTF are waiting in line and that a comet mission is also getting ready.

But how are we going to deal with this situation? Do we just slip everything back a year? We hope to get some guidance on this and other matters, and I will introduce the second panel later. So we want to start with the first panel.

Would you all please come up to the table? Bob Walker, our ranking member, will be here shortly, and he has an opening statement which we will insert without objection in the record.

[The prepared opening statement of Mr. Walker follows:]

OPENING STATEMENT OF HON. ROBERT S. WALKER, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF PENNSYLVANIA

Good afternoon, Mr. Chairman, Despite a spirited defense of the proposed budget for space science and applications I remain concerned about the lack of high priority new starts in the budget for 1986.

We had expected to see two important projects in this budget. The first is the Ocean Topography Experiment known as TOPEX and the International Solar Terrestrial Phycics Program known as ISTP.

The TOPEX experiment is an exciting and important oceanographic initiative for NASA in collaboration with the French.

The ISTP mission is to be a major examination of the interchange and transport of energy in the solar-terrestrial system. This mission is particularly important because we expect significant participation by both the European Space Agency and the Intitute of Space and Astronautical Science of Japan. Only last week this Committee was visited by several members of the Japanese Diet who expressed strong interest in these joint projects.

There is concern in the international community that the United States is not the most dependable partner in technological ventures. Part of our problems are based on budget constraints beyond NASA's control. But we also need to set our scientific priorities in such a way as to assure steady progress.

Finally, Mr. Chairman, I would like to thank our witnesses this afternoon for both their testimony, which helps us make difficult policy choices, and for their dedication to public service in acting as the honest broker in the area of Space Science and Applications.

Mr. NELSON. Dr. Donahue.

STATEMENTS OF DR. THOMAS DONAHUE, CHAIRMAN, SPACE SCIENCE BOARD, NATIONAL ACADEMY OF SCIENCES; DR. LOUIS LANZEROTTI, BELL TELEPHONE LABORATORIES; AND DR. ARTHUR F. DAVIDSEN, PROFESSOR OF PHYSICS, JOHNS HOPKINS UNIVERSITY

Dr. DONAHUE. Thank you, Mr. Chairman, Mr. Nelson, and members of the subcommittee. Thank you for inviting me to appear today alongside my distinguished colleagues, Dr. Davidsen and Dr. Lanzerotti.

This year we certainly have to commend NASA and the administration for sending to you a forward-looking proposal for the agency as a whole and for space science in particular. There are increases in virtually all lines of the budget.

For example, this year we don't have to request you to restore cuts in research and analysis or mission operations and data analysis. In the past few years, the levels requested were in some cases lower than those you authorized and appropriated the previous year. We want to thank you for your persistence in keeping these vital programs viable in the past and to congratulate the administration for adopting that policy this year.

This coming fiscal year should be a great one in many ways for our space science program. Missions launched in years past, such as Pioneers 10 and 11, Pioneer Venus, Voyager, the International Comet Explorer, the Active Magnetospheric Particle Tracer Explorer and the Solar Maximum Mission should still be providing valuable information about the solar system and the universe.

ICE will encounter the comet, Giacobinni-Zinner, this September; Voyager 2 will arrive at Uranus to provide us with our first close look at that planet. The Hubble space telescope will, we all hope, be launched. So will Galileo and the European Ulysses spacecraft which should be on a first-class mission even though it has been deprived of its very important American counterpart.

After saying all of these good things, it is embarrassing in this year of fiscal stringency that I cannot pretend that everything about this budget is superb. It is a truism that space science cannot survive without flight opportunities. There are none offered in the 1986 budget. New starts for the ocean topography experiment [TOPEX], for the International Solar-Terrestrial Program [ISTP] and for gravity probe B have not been requested. In a normal budget year you surely would have seen proposals for at least two of these. This is not a normal year, and we recognize the economic and political factors which influenced this decision.

However, it is clear that postponing the initiation of these missions will create a very great traffic jam in future years. The advanced X-Ray Astronomy Facility [AXAF], the Comet Rendezvous and Asteroid Fly-By Mission, the Geopotential Research Mission [GRM], the Space Infrared Telescope Facility [SIRTF), all are well studied missions designed to address questions of high scientific priority that are also waiting in line. If I take the optimistic view that the ban on new starts will be lifted next year, as I must, then I must strongly recommend that a careful plan be developed to get these missions underway—along with at least one more solar system observer mission on the Solar System Exploration Committee's list—during the next 5 years.

These highly visible large projects are not the only ones being delayed. It is also very serious that we just don't seem to be making satisfactory progress in getting small P-I class experiments flown on the shuttle at a high rate, or any rate at all. Nor do we see the long awaited announcement of opportunity for new Explorer missions, or satisfactory progress in developing the approved Extreme Ultraviolet Explorer [EUVE]. Thus, space science is still suffering from the lack of flight opportunities that can be traced back to the delays in getting the shuttle operational and make it so difficult to maintain coherence in academic space research programs or in an industrial base of support.

One last complaint and I shall return to a more positive tone. I note that of the three recommendations of the NASA-University Relations Committee, only the one for graduate student fellowships is being implemented. The supplemental appropriations for laboratory equipment and for data analysis were not forthcoming last year and are not to be found in this budget request either. The result is that university laboratory equipment, which was in a state of almost serious obsolescence a couple of years ago, is in a state of even greater decrepitude.

On a positive note, I can report to you that our Committee on Solar and Space Plasma Physics has completed a planning exercise for its disciplines, similar to those carried out by the astronomy survey committee and the Solar System Exploration Committee. Its report, entitled "An Implementation Plan for Priorities in Solar System Space Physics," is presently being reviewed by the NRC, and we shall be eager to let you have its recommendations as soon as that process is completed.

The report outlines a prioritized program for future missions and analysis activities through the year 2000, which is characterized by stability, feasibility, and affordability. The scientific community in this area, like those involved in the planetary and astronomy exercise, has tried to face up to the hard choices of putting together a program which addresses only the highest priority science within a realistic budget level. Thus, the space science community now has in place a road map for a national research program in solar and space physics, a program that complements those in astronomy and planetary exploration.

Looking ahead further into the future, a decade or more ahead, I see brighter things. The Space Agency established a committee under Prof. Peter Banks of Stanford University to advise it concerning how to configure the space station so that it would be useful for science. The Space Science Board has followed the work of this committee closely and is very pleased with the wisdom of the advice it has generated. We sense a strong commitment on the part of Mr. Beggs, Mr. Culbertson, and Dr. Edelson to heed that advice. If they do, the space station should provide a very useful base from which we shall be able to service, maintain, and refurbish the space science platforms and free flyers of the future, where large complex structures can be assembled and launched and where exciting scientific studies in life sciences and some physical science disciplines, such as cosmic ray physics, can be pursued.

As long as all involved remain committed to these positive properties of the space station and determined not to compromise science requirements by artificially distorting them to match the convenience of some particular space station architecture, we should arrive at the mid-nineties in good shape. As I have repeatedly stated, however, this will be true provided space science missions continue to be carried out at a reasonable rate between now and then.

Mr. NELSON. Doctor, we have a vote. It looks like there are two votes. The first one is a 15-minute vote, of which 6 minutes have already expired. The second one is a 5-minute vote, which should come shortly thereafter. So we are going to recess the committee, go cast our votes, and we will be right back, and we will resume with you right there on page 5.

Dr. DONAHUE. Thank you, sir.

Mr. NELSON. And we appreciate your testimony.

[Recess.]

Mr. NELSON. The committee will resume.

Dr. Donahue, if you will please continue.

Dr. DONAHUE. I was at the point of looking a little bit further ahead, and I can report doing that, but the long-range study that we have been asked to undertake in order to identify the directions that major efforts in space science should be taking in the two decades after 1995 is well underway. Task groups have been formed in astronomy and astrophysics, in solar system exploration, in solar and space plasma physics, in life sciences, in earth sciences, and in relativity and basic physics and chemistry. They have met for 10 days last summer and 3 days in January. Their work will not be finished until June 1986.

However, it is already clear that stretching ahead as far as we can see, a space research program could readily be justified on purely scientific grounds that is much more extensive than any likely to be allocated the resources needed to support it. We should be happy to brief you on our progress in more detail at any time.

The Space Science Board is often asked to comment on the balance in NASA's space science program. This is easy to do if one or more disciplines that represent good science are receiving such an inadequate share of resources that their viability is threatened. For example, space plasma physics may drop to this level if ISTP does not get underway within the next couple of years. Solar system exploration was threatened with extinction a few years ago. Within a discipline—astronomy—the high energy community has been starved for data too long. These are examples. In cases like these it is relatively easy to arouse the entire scientific community to support the ailing member and restore balance in this sense.

But whenever we address the question of whether a body like the Space Science Board, with its representatives of all space science disciplines, could develop proposals for priorities across disciplines, we quickly conclude that there are no scientific criteria we could develop for the task. We are experts at setting priorities within any one field of science. This is what I think we do rather well. However, the astronomer, for example, finds it difficult to judge impartially the value of science missions in Earth and life sciences relative to his own discipline.

We are able to recognize the potential of fields not currently very active in using space science vehicles to develop strength by doing so and to encourage them by measures such as increasing the number of representatives on the Board or establishing a standing committee to develop science strategy. But it seems to us that the ultimate judgments about priorities and whether balance is maintained as a result of exercising priorities, are made adequately by the present method of relying on a complex democratic process to make essentially political decisions. Fortunately that process is a dynamic one and lends itself to regular appeal and adjustment.

In the spirit of playing our part in that process, I should tell you that our greatest concern for balance in the space science program for the past several years has been with regard to the space plasma physics discipline. Ever since a reorganization of the science management structure at NASA Headquarters occurred some years ago that deprived that activity, along with Solar Physics, of division status, there has been a concern in the relevant community that the interest of those sciences were not adequately represented at NASA. The community would probably agree that the test of the validity of its concerns is whether ISTP survives the hazards of the budget process during the next couple of years. There are many, however, who would prefer not to take the risk of failure and who press for administrative changes now.

Where administrative changes are concerned, the Board is in general pleased with recent developments regarding science management at NASA Headquarters. If a plan is implemented to make use of detailees from universities at NASA similar to the one in effect at the National Science Foundation, we feel that a good step toward stabilizing the science management process will have been taken.

For this plan, as well as for all of the other positive elements in the 1986 budget request, we congratulate NASA and commend the request to you.

This ends my statement. Thank you very much, Mr. Chairman. I would be pleased, of course, to respond to questions.

[The prepared statement of Dr. Donahue follows:]

STATEMENT BY

Thomas M. Donahue
Chairman, Space Science Board
National Academy of Sciences

BEFORE THE

Subcommittee on Space Science and Applications
Committee on Science and Technology
U.S. House of Representatives

FY 86 NASA BUDGET REQUEST

Tuesday, February 26, 1985
Room 2325, Rayburn House Office Building

Mr. Chairman and members of the subcommittee. Thank you for inviting me to appear here this morning alongside my distinguished colleagues, Dr. Davidsen and Dr. Lanzerotti. I am sure you know that I am the Chairman of the Space Science Board of the National Research Council. The Board is charged with advising NASA and other elements of our government with responsibility for our space program about scientific issues in that program. In carrying out that charge I have the pleasure of interacting with your subcommittee every year at about this time in order to discuss the President's budget proposal for space science.

This year we certainly have to commend NASA and the administration for sending to you a forward-looking proposal for the agency as a whole and for space science in particular. There are increases in virtually all lines of the budget. For example, this year we do not have to request you to restore cuts in Research and Analysis or Mission Operations and Data Analysis to levels. In the past few years the levels requested were in some cases lower than those that you authorized and appropriated the previous year. We want to thank you for your persistence in keeping these vital programs visible in the past and to congratulate the administration for adopting that policy this year.

This coming fiscal year should be a great one in many ways for our space science program. Missions launched in years past, such as Pioneers 10 and 11, Pioneer Venus, Voyager, The International Comet Explorer (ICE), the Active Magnetospheric Particle Tracer Explorer (AMPTE), and the Solar Maximum Mission should still be providing valuable information about the solar system and the universe: ICE will encounter the comet, Giacobinni-Zinner, this September; Voyager 2 will arrive at Uranus to provide us with our first close look at that planet. The Hubble Space Telescope will, we all hope, be launched. So will Galileo and the European Ulysses spacecraft which should be on a first class mission even though it has been deprived of its very important American counterpart.

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On a positive note I can report to you that our Committee on Solar and Space Plasma Physics has completed a planning exercise for its disciplines, similar to those carried out by the Astronomy Survey Committee and the Solar System Exploration Committee. Its report, entitled "An Implementation Plan for Priorities in Solar System Space Physics", is presently being reviewed by the NRC and we shall be eager to let you have its recommendations as soon as that process is completed. The report outlines a prioritized program for future missions and analysis activities through the year 2000, which is characterized by stability, feasibility, and affordability. The scientific community in this area, like those involved in the planetary and astronomy exercise has tried to face up to the hard choices of putting together a program which addresses only the highest priority science within a realistic budget level. Its major elements involve both exploration (for example, a probe to the vicinity of the sun), and intensive studies of the chain of interaction from the sun through the interplanetary medium to the magnetosphere, ionosphere and upper atmosphere of the Earth (for example, the upper atmosphere research satellite (UARS) and the international solar terrestrial physics program (ISTP)). Thus, the space science community now has in place a road map for a national research program in solar and space physics, a program that complements those in astronomy and planetary exploration.

Looking ahead further into the future -- a decade or more ahead -- I see brighter things. The Space Agency established a committee under Professor Peter Banks of Stanford University to advise it concerning how to configure the Space Station so that it would be useful for science. The Space Science Board has followed the work of this committee closely and is very pleased with the wisdom of the advice it has generated. We sense a strong commitment on the part of Mr. Beggs, Mr. Culbertson and Dr. Edelson to heed that advice. If they do, the Space Station should provide a very useful base from which we shall be able to service, maintain, and refurbish the space science platforms and free flyers of the future, where large complex structures can be assembled and launched and where exciting scientific studies in life sciences and some physical science disciplines, such as cosmic ray physics can be pursued. As long as all involved remain committed to these positive properties of the Space Station, and determined not to compromise science requirements by artificially distorting them to match the convenience of some particular Space Station architecture we should arrive at the mid-nineties in good shape. As I have repeatedly stated, however, this will be true provided space science missions continue to be carried out at a reasonable rate between now and then.

Looking even further ahead I can report that the long range study that we were asked to undertake in order to identify the directions that major efforts in space science should be taking in the two decades after 1995 is well underway. Task groups have been formed in astronomy and astrophysics, in solar system exploration, in solar and space plasma physics, in life sciences, in earth sciences and in relativity and basic physics and chemistry. They have met for ten days last summer and three days in January. Their work will not be finished until June of 1986. However, it is already clear that stretching ahead as far as we can see, a space research program could readily be justified on purely scientific grounds that is much more extensive than any likely to be allocated the resources needed to support it. We should be happy to brief you on our progress in more detail at any time.

The Space Science Board is often asked to comment on the balance in NASA's space science program. This is easy to do if one or more disciplines that represent good science are receiving such an inadequate share of resources that their viability is threatened. For example, Space Plasma Physics may drop to this level if ISTP does not get underway within the next couple of years. Solar System Exploration was threatened with extinction a few years ago. Within a discipline -- astronomy -- the high energy community has been starved for data too long. These are examples. In cases like these it is relatively easy to arouse the entire scientific community to support the ailing member and restore balance in this sense. But whenever we address the question of whether a body like the Space Science Board with its representatives of all space science disciplines could develop proposals for priorities across disciplines, we quickly conclude that there are no scientific criteria we could develop for the task. We are experts at setting priorities within any one field of science. This is what I think we do rather well. However, the astronomer, for example, finds it difficult to judge impartially the value of science missions in earth and life sciences relative to his own discipline. We are able to recognize the potential of fields not currently very active in using space science vehicles to develop strength by doing so and to encourage them by measures such as increasing the number of representatives on the Board or establishing a standing committee to develop science strategy. But it seems to us that the ultimate judgments about priorities, and whether balance is maintained as a result of exercising priorities, are made adequately by the present method of relying on a complex democratic process to make essentially political decisions. Fortunately, that process is a dynamic one and lends itself to regular appeal and adjustment.

In the spirit of playing our part in that process I should tell you that our greatest concern for balance in the space science program for the past several years has been with regard to the Space Plasma Physics discipline. Ever since a reorganization of the science management structure at NASA Headquarters occurred some years ago that deprived that activity along with Solar Physics of division status, there has been a concern in the relevant community that the interest of those sciences were not adequately represented at NASA. The community would probably agree that the test of the validity of its concerns is whether ISTP survives the hazards of the budget process during the next couple of years. There are many, however, who would prefer not to take the risk of failure and who press for administrative changes now.

Where administrative changes are concerned the Board is in general pleased with recent developments regarding science management at Headquarters. If a plan is implemented to make use of detailees from universities at NASA similar to the one in effect at the National Science Foundation, we feel that a good step toward stabilizing the science management process will have been taken.

For this plan, as well as for all of the other positive elements in the 1986 budget request, we congratulate NASA and commend the request to you.

This ends my statement. Thank you very much, Mr. Chairman. I would be pleased, of course, to respond to questions.

Mr. **Nelson**. Thank you, Dr. Donahue.

Dr. Lanzerotti.

Dr. **Lanzerotti**. Mr. Chairman, and members of the subcommittee, thank you for inviting me to appear before you this afternoon with my colleagues.

The Space and Earth Science Advisory Committee [SESAC] of NASA is the internal advisory committee responsible for overseeing the Space and Earth Sciences Program. It reports to the NASA Advisory Council and works directly with the Associate Administrator for the Office of Space Science and Applications.

The SESAC is an advisory body parallel to the National Academy of Sciences' Space Science Board, chaired by Professor Donahue. In general, the Space Science Board has been concerned with the long-range scientific planning and strategy for United States space science programs. In contrast, SESAC has defined its role as being concerned with the near-term programmatic issues, addressing such areas as new start priorities, the health of space science vis-a-vis flight opportunities and research and analysis support, and the apportionment of resources within discipline areas and research opportunities, whether involving space flight, research and analysis or new instrument development.

As an example of its role of addressing programmatic matters, last year the SESAC studied one of the longstanding concerns of the science community—that of support for scientific research and analysis independent of major space flight projects. A report issued by SESAC, after a thorough review of the NASA R&A program and of the roles of the NASA Headquarters science discipline offices, contained several important recommendations including that OSSA should give its research and analysis program a priority commensurate with that of the flight programs.

That leads me directly into commenting more on the budget process and the prioritization process, and I will come back to the R&A.

The SESAC has normally been requested by the Associate Administrator for the OSSA to actively discuss and to prioritize major new budget initiatives that are under discussion prior to the NASA submittal to the administration. These discussions relative to the fiscal year 1986 budget now under consideration by your subcommittee occurred in June 1984 and resulted in principal recommendations to the Associate Administrator and to the NASA Advisory Council for new starts for the TOPEX and ISTP missions and for augmentation of the research and analysis budget, as you well know.

The TOPEX mission would be a major new and important oceanographic initiative for the agency and for U.S. oceanographic research and has an important collaboration with the French. The ISTP mission, with large international cooperation from both the European Space Agency and the Japanese Institute of Space and Astronautical Science of Japan, would provide significant enhancement of understanding of the interchange and transport of energy in the solar-terrestrial system, as discussed by Dr. Donahue. The SESAC stressed, consistent with its research and analysis report, that the augmentation request for research and analysis was to be considered of equal importance with the new start candidates.

The SESAC and myself personally are very pleased that the proposed fiscal year 1986 budget, with its requested increase for research and analysis, recognizes the importance of this area to NASA's overall mission and hopes that such increase in research and analysis and consideration commensurate with the flight projects will be considered in future years as well. The budget continues support for many activities which will make 1986 an outstanding year for U.S. space science.

I believe that the space science community understands and largely supports the national mood toward a constrained budget in order to have a healthier national climate in the future, the factor which mitigated against new starts in the proposed budget. Unfortunately, however, delay in the initiation of new projects, which have been honed and prioritized, often several times over, by their respective science communities, produce strains in the communities in a number of ways, including future engineering manpower availability and graduate student continuity and research project support.

Delays in programs in one discipline in a given year will produce ripple delay effects into other space science disciplines that have been proceeding in orderly fashion to bring their own programs to the level of new start readiness. Ultimately, delays produce a coalescing of a number of ready new opportunities, which you alluded to, a situation which creates tensions between science communities, threatening the attempts to achieve balanced, first-rate science opportunities in all disciplines.

From a policy standpoint, delays in major science programs with significant foreign interest and participation produce significant questions of U.S. reliability as a science partner and reduce future opportunities for collaborative foreign space endeavors. I have personally experienced severe questioning by foreign associates on this matter relative to some recent past and present programs.

I would like to go on very briefly. SESAC has undertaken some more complicated discussions of the space science program and programmatic issues related to the health of the U.S. space science program. The nature of space science research in the U.S. is changing, driven by a number of external, as well as intrinsic, factors. The SESAC believes it is now most appropriate to carefully think through the implications of the changes taking place and to develop some positions on behalf of the U.S. space science community that it can recommend to NASA, as it did for the more well-defined research and analysis issue. In particular, SESAC has accepted that the principal responsibility of the Office of Space Science and Applications is to promote and conduct the highest quality possible program of science in space. The committee has then identified the following as the major programmatic issue to be discussed:

> What is the best means to insure the continued progress of science disciplines in space given the advent of new capabilities, long-lived missions such as observatories and deep space probes, the existence of large funding fluctuations associated with big missions, and the initiation of the space station and other major new programs?

Under this the committee has further identified three major questions for U.S. space science which arise from this issue. The first of these, "What is NASA's role in a national program of science in space (a) with respect to national capabilities in science disciplines, and (b) among agencies?" the committee believes is best left at this time to the ongoing work of NASA itself and of OSTP.

The second question, "What is the role of the space station in the space and earth science program?" has the potential for a major impact on the entire science program and is being partially addressed by the Space Station Task Force of SESAC, as well as SESAC itself.

The SESAC has decided to concentrate a major part of its attention on the third major question which it identified, as this question contains most of the detailed programmatic elements which affect the health of space science research and institutions on a day-to-day basis. That is, "In order to achieve the best science program possible in the future, what is the best way to achieve optimum balance across disciplines, among experiment opportunities, within the available skills of participating institutions?"

SESAC has been meeting for the last 2½ days, and we have no answer at this point, Mr. Chairman. Hopefully, a year from now we will have some answers that we can give to NASA that quantify more vigorously in a better way and in a programmatic way consistent with our charge, these questions, so that the nation will have a better foundation to assess priorities within and among disciplines and among experiment opportunities.

This process is just beginning, and I look forward to a difficult but hopefully fruitful ending of it within the next year or so.

Thank you.

[The prepared statement of Dr. Lanzerotti follows:]

Statement
to
Subcommittee on Space Science and Applications
Committee on Science and Technology

U.S. House of Representatives

by

Louis J. Lanzerotti
AT&T Bell Laboratories
Chairman, Space and Earth Science Advisory Committee
of the
NASA Advisory Council

27 February 1985

Mr. Chairman and members of the Subcommittee, thank you for inviting me to appear before you this morning. The Space and Earth Science Advisory Committee (SESAC) of NASA is the internal advisory committee responsible for overseeing the space and Earth science program. It reports to the NASA Advisory Council and works directly with the Associate Administrator for the Office of Space Science and Applications (OSSA). The SESAC is an advisory body parallel to the National Academy of Sciences' Space Science Board. In general, the Space Science Board has been concerned with the long-range scientific planning and strategy for United States' space science programs. In contrast, SESAC has defined its role as being concerned with near-term programmatic issues, addressing such areas as new start priorities, the health of space science vis-a-vis flight opportunities and research and analysis support, and the apportionment of resources within discipline areas and research opportunities, whether involving space flight, research and analysis or new instrument development.

As an example of its role of addressing programmatic matters, last year the SESAC studied one of the long-standing concerns of the science community — that of support for scientific research and analysis independent of major space flight projects. A report issued by SESAC after a thorough review of the NASA R&A program and of the roles of the NASA headquarters science discipline offices, contained several important recommendations, including that (a) OSSA should give its Research and Analysis Program a priority commensurate with that of the flight programs, and (b) the management of the research and analysis programs should remain at NASA headquarters (rather than be transfered to NASA centers), in order to provide the oversight, coordination, and planning mandatory for an effective national program. Both of these recommendations appear to be being seriously addressed by NASA.

I now would like to provide some thoughts on the proposed FY1986 NASA budget as it relates to the space and Earth science program.

The SESAC has normally been requested by the Associate Administrator for the OSSA to actively discuss, and to prioritize, major new budget initiatives that are under discussion prior to the NASA submittal to the Administration. These discussions relative to the FY1986 budget now under consideration by Congress occurred in June 1984 and resulted in principal recommendations to the Associate Administrator and to the NASA Advisory Council for new starts for the TOPEX and ISTP missions and for augmentation of the research and analysis budget. The TOPEX mission would be a major new and important oceanographic initiative for the agency and for U.S. oceanographic research, and has an important collaboration with the French. The ISTP mission, with large international cooperation from both the European Space Agency and the Institute of Space and Astronautical Science of Japan, would provide significant enhancement of understanding of the interchange and transport of energy in the solar-terrestrial system. The SESAC stressed, consistent with its research and analysis report, that the augmentation request for research and analysis was to be considered of equal importance with the new start candidates.

The SESAC, and myself personally, are very pleased that the proposed FY1986 budget, with its requested increase for research and analysis, recognizes the importance of this area to NASA's overall mission. The budget continues support for many activities which will make 1986 an outstanding year for U.S. space science. The Voyager 2 spacecraft will encounter Uranus while Voyager 1 continues on its trip out of the solar system. The FY1986 budget begins plans for the Voyager 2 encounter with Neptune in 1989. The Ulysses mission will be launched on its voyage out of the ecliptic, over the poles of the sun, while the Galileo mission will be launched toward its dedicated, detailed studies of Jupiter's atmosphere, satellites, and magnetosphere, after first flying close to the asteroid Amphitrite. Halley's comet will be studied with ground- and shuttle-based telescopes. The launch of the Hubble Space Telescope, planned for August 1986, will, for astronomy, usher in a new era whose impact on our understanding of the universe can only be dimly perceived at present. The continued support in the proposed budget of major initiatives recently begun, such as the important solar optical telescope, the Venus Radar Mapper, the Upper Atmosphere Research Satellite, and the Mars geochemical orbiter are very healthy signs for space science across a range of disciplines. The budget appears to provide for an increasingly active shuttle/spacelab program, although some experiments are likely to have to continue to wait for flight opportunities that were expected long ago.

I believe that the space science community understands and largely supports the national mood toward a constrained budget in order to have a healthier national climate in the future, the factor which mitigated against new starts in the proposed budget. Unfortunately, however, delay in the initiation of new projects, which have been honed and prioritized, often several times over, by their respective science communities, produce strains in the communities in a number of ways, including future engineering manpower availability and graduate student continuity and research project support. Delays in programs in one discipline in a given year will produce ripple delay effects into other space science disciplines that have been proceeding in orderly fashion to bring their own programs to the level of new start readiness. Ultimately, delays produce a coalescing of a number of ready new opportunities, a situation which creates tensions between science communities, threatening the attempts to achieve balanced, first rate science opportunities in all disciplines. From a policy standpoint, delays in major science programs with significant foreign interest and participation produce significant questions of U.S. reliability as a science partner and reduce future opportunities for collaborative foreign space endeavors. I have personally experienced severe questioning by foreign associates on this matter relative to some recent past and present programs.

I turn now to some of the important programmatic issues related to the health of U.S. space science that SESAC is beginning to address and which bear importantly upon the above discussion.

The nature of space science research in the U.S. is changing, driven by a number of external, as well as intrinsic, factors. The SESAC believes it is now most appropriate to carefully think through the implications of the changes taking place and to develop some positions, on behalf of the U.S. space science community, that it can recommend to NASA, as it did for the more well-defined research and analysis issue. In particular, SESAC has accepted that the principal responsibility of the Office of Space Science and Applications is to promote and conduct the highest quality possible program of science in space. The Committee has then identified the following as the major programmatic issue to be discussed:

> "What is the best means to insure the continued progress of science disciplines in space given the advent of new capabilities, long-lived missions such as observatories and deep space probes, the existence of large funding fluctuations associated with big missions, and the initiation of the space station and other major new programs?"

The Committee has further identified three major questions for U.S. space science which arise from this issue. The first of these,

> "What is NASA's role in a national program of science in space (a) with respect to national capabilities in science disciplines, and (b) among agencies?",

the Committee believes is best left at this time to the on-going work of NASA itself and of OSTP.

The second question,

> "What is the role of the space station in the space and Earth science program?",

has the potential for a major impact on the entire science program and is being partially addressed by the Space Station Task Force of SESAC.

The SESAC has decided to concentrate a major part of its attention on the third major question which it identified, as this question contains most of the detailed programmatic elements which affect the health of space science research and institutions on a day-to-day basis. That is,

> "In order to achieve the best science program possible in the future, what is the best way to achieve optimum balance
>
> (a) across disciplines?
>
> (b) among experiment opportunities?
>
> (c) within the available skills of participating institutions?"

We must first identify the space science disciplines of which we speak. As an operational definition I take the following as the four major disciplines: astrophysics, solar-terrestrial, planetary, and Earth science (these are also the categories used in a recent report from the OSTP in discussions of the present allocation of resources among the science disciplines; they do not correspond to NASA's budgeting lines or organizational structure for OSSA). In general, in the past, NASA has pursued, with the concurrence of the science discipline communities, a policy of balance among these disciplines in terms of new start opportunities. SESAC will examine this in the light of present discipline needs and science opportunities.

With regard to the second point, the science disciplines can require very different types of flight opportunities in order to pursue their scientific objectives. An examination of these opportunities is mandatory now, when the shuttle is nearing operational status and the space station is beginning to be designed. It is necessary to insure that these two opportunities are not the sole determinant of the types of science the nation will conduct. Near-Earth orbital platforms can be ideal for certain disciplines, such as Earth observations and astrophysics, but do not contribute to carrying out major science objectives of other disciplines, such as most of planetary science or in-situ measurements of the solar-terrestrial environment, including the solar wind and the Earth's magnetosphere. Even for astrophysics, which can use to good advantage a low Earth orbit, there are research objectives which require different types of flight opportunities ranging from Spartans, ejected by the Shuttle, to large free-flying telescope observatories. SESAC intends to examine in some detail the spectrum of flight opportunities required to maintain the vitality of each science discipline.

The institutions participating in NASA's space science program include universities, industrial laboratories, and NASA centers and other federal laboratories. SESAC will examine the unique contributions that each of these institutions bring to bear on our national space science effort. University-based research has rightly had, from my perspective, a special relationship in NASA science programs. Given the changing science environment, and the unique character and capabilities of the research universities, what should the role of the educational institutions be in the future in our national space effort? SESAC expects to arrive at some conclusions on this, which can then be used by NASA in carrying out its mandate.

I expect that by approximately this time next year SESAC will begin to have some definite recommendations to make on these important programmatic issues for the health of the nation's space science program. I hope my discussion of these matters with you this morning has been helpful for your assessments of the U.S. space science program and for your understanding of some of the major programmatic issues that face it. I am confident that the results of SESAC's deliberations on these matters this coming year will contribute importantly to the growth and flourishing of the program in the future.

Mr. NELSON. Thank you so much, Dr. Lanzerotti.

Dr. Arthur Davidsen.

Dr. DAVIDSEN. Mr. Chairman, and members of the subcommittee, thank you for the opportunity to appear before you this afternoon to testify on NASA's budget request for fiscal year 1986.

I am here in my capacity as a member of the steering committee of the Space Science Working Group, a consortium of 21 of the Nation's major research universities who are involved in NASA's space science programs.

As members of the university community, our concern has been for the health of the sciences to which we are dedicated, and particularly for the continued strength of our universities which play a unique and critical role in America's future in space. From our universities come many of the ideas which will shape that future, and our students are the people who will make that future a reality. And through our universities the great discoveries of the Space Program are transmitted to the next generation.

At our meeting last week, the mood of the Space Science Working Group was subdued. Well aware of the climate of severe budgetary restraint which pervades the Nation this year, we are grateful that the current budget proposal imposes no draconian cuts in NASA's space science programs. In past years we have felt that certain budget omissions would create severe immediate problems for the health of space science in the Nation. We have come to the Congress for help, and the Congress has responded.

This year, however, we see no immediate crisis which, in the present budgetary environment, would justify our asking for your help. This year we are resigned, if not content, to accept a budget which, if passed as it is proposed, is at least minimally adequate to continue programs already underway.

The NASA Space Science Program, we concluded, is on a ballistic trajectory for 1986. Superficially this may sound good, but in reality it means the rocket engines have been shut off, and we are just coasting. We are constrained to follow a trajectory which was determined by our planning and actions in the past. With this budget proposal, nothing new enters the equation of our motion. And as long as no new energy or momentum is added to our projectile, its path will eventually come to be recognized for what it really is—free fall.

No matter that its present course looks even upward, with several spectacular achievements expected in the coming year, including the Voyager fly-by of Uranus, shuttle and ground-based observations of Halley's Comet, the launch of the Galileo spacecraft to Jupiter, and the launch of the Hubble Space Telescope. We should be euphoric as we approach these new heights, and we are. At the same time, we must remember that there will be no new heights in the future unless we invest some resources now. Our Nation's space science enterprise is strong, and it can probably survive by coasting for a year, but it will require more energy next year if it is to avoid slipping into free fall.

The Space Science Working Group's concern results, of course, from the lack of any new starts for space science, as already alluded to by my colleagues, in the proposed budget for fiscal year 1986. Such new starts do not represent an expansion of our efforts, but simply provide the necessary momentum to keep the space sciences steadily advancing.

When programs which have been brought to the stage of being ready for a new start are left dangling, as several are now, the progress of our whole space research enterprise is impeded, since Research & Analysis [R&A] funds which could have been used for other new purposes are tied up supporting the waiting period of the new start candidates. If this waiting period is too long, the results can be disastrous, both for the projects not started and for all of the other activities which are slowed as a result.

Furthermore, the fierce competition which will tend to arise naturally next year or the year after among several new start candidates in different branches of space science is not a healthy situation. Competition is fine when we want to see who is best or strongest. But there is no objective way of assigning values to the different disciplines which make up the broad field of endeavor we call space science. We must, therefore, treat these various disciplines as we treat our children and encourage them not to compete with each other but to compete with themselves to become the best that they can be. It is usually best if your children are not all trying to get into the same college in the same year.

Our concern for the future health of the space sciences in this Nation does not end with the lack of a major new project start in the proposed budget. Another concern arises from the continuing lack of frequent, low-cost flight opportunities aboard the space shuttle. We believe that the importance of flight opportunities to the university space research community is not fully appreciated. Such opportunities give us the chance to take many small steps forward and to prepare for the leaps that the big programs provide. It is in these small, frequent projects that we can develop new ideas and new instruments and provide hands-on experience with space flight hardware for our students.

It is also through such flight programs that many of us derive the most of the funding which helps to support the people, the activities, and the instrumentation in our laboratories. The last major solicitation of experiments for the space shuttle was conducted in 1978, and none of the experiments selected has yet been flown. It is clear that the shuttle has so far not provided the quick and easy access to space that is necessary for a productive space science program.

NASA is aware of this problem, and a recent report of the NASA Advisory Council's Shuttle Science Working Group reviews the situation and makes several recommendations. The Space Science Working Group strongly supports the findings and recommendations of the report, which include an estimate that a healthy program of shuttle-borne science will need about $25 million per year in the near future. If we are to effectively use the space station for science in the future, we must learn to use the shuttle for science now. NASA needs a Frequent Flyer Program in 1986 if it is to have many experienced and loyal passengers for the space station in 1996.

I would now like to turn to a theme which the Space Science Working Group has repeated each year. The big space programs which receive so much public attention stand on a broad base of scientific activities which are supported by the Research and Analysis Program in NASA. Without a firm foundation of research and analysis, the spectacular advances of which we are so justifiably proud would not be possible. The R&A programs support the formulation of new scientific questions to be asked, the early conceptualization of missions which can address those questions, the analysis of data from ongoing and completed missions, and the development of theoretical understanding of the results obtained.

This then leads back again to new scientific questions. It may seem sometimes as if we are simply going round in circles, but the path of our progress is better described by a helix. With each new turn we move to a higher plane in which the scientific questions become more profound, the missions become more challenging and expensive, the data analysis becomes more difficult, and the understanding we achieve grows deeper. This is the essence of the scientific enterprise. As we climb up the helix, the path becomes steeper, and we find that we must work harder and invest more energy and resources to continue to advance. We cannot continue to reach these higher planes by coasting.

For some time now the support for research and analysis programs in the space sciences has been steadily eroding. This is highlighted in the July 1984 report of NASA's Space and Earth Science Advisory Committee on Research and Analysis in the Space and Earth Sciences described by Dr. Lanzerotti. The Space Science Working Group agrees with the findings and recommendations expressed in the report. We must begin soon to reverse this long-term trend if we are to maintain the health of our Nation's investment in the space sciences.

As I stated earlier, universities train the future generations of scientists and engineers. We must increase our support for students in the space sciences or we will have no cadre to continue the achievements of our past. NASA recently established a new component of its Graduate Student Researchers Program which will provide financial support to graduate students studying in fields related to space science. We would like to acknowledge and commend this initiative. The program should be given continued support and permitted to grow.

Also, we must find a way to improve the deteriorating state of the equipment and instrumentation in our university laboratories. Unfortunately, I can report that nothing has been done so far in this direction that I am aware of.

It appears that this may not be a year in which to hope for substantial improvements in these long-term problems. But these are not problems which have developed overnight or in 1 year, and they will not be solved in 1 year either. The requirements for addressing these long-term problems have been identified in the reports of several panels which I cited earlier. Each year that these problems are not addressed, they become more critical and difficult to solve. We are prepared to wait for another year and to watch our scientific enterprise coast for a little way, but we also clearly recognize that this cannot be allowed to continue for long. We urge NASA and the Congress to begin planning a solution now.

[The prepared statement of Dr. Arthur F. Davidsen follows:]

Statement
to the
Subcommittee on Space Science and Applications
Committee on Science and Technology
U.S. House of Representatives

by

Dr. Arthur F. Davidsen
Director, Center for Astrophysical Sciences
Professor of Physics and Astronomy
and
Member of the
Space Science Working Group

26 February 1985

BIOGRAPHY OF DR. ARTHUR F. DAVIDSEN

Dr. Arthur F. Davidsen is Director of the Center for Astrophysical Sciences and Professor of Physics and Astronomy at the Johns Hopkins University, Baltimore, MD. He holds degrees from Princeton University and the University of California at Berkeley. He has taught at the Johns Hopkins University since 1975 and led the University's efforts to establish the Space Telescope Science Institute (STScI) on its campus. He is Principal Investigator of the Hopkins Ultraviolet Telescope to be launched aboard the Space Shuttle in FY 1986 as part of NASA's ASTRO Observatory. He is a Co-Investigator on several other NASA-sponsored projects, including the Faint Object Spectrograph for the Hubb'e Space Telescope. He has served on numerous advisory panels, boards and committeess and is currently a member of the Steering Committee of the Space Science Working Group.

Mr. Chairman and members of the Subcommittee, thank you for the opportunity to appear before you this afternoon to testify on NASA's budget request for FY 1986. I am here in my capacity as a member of the Steering Committee of the Space Science Working Group, a consortium of 21 of the nation's major research universities who are involved in NASA's space science programs. The Space Science Working Group is an activity of the Association of American Universities. Each year since its foundation three years ago, the Space Science Working Group has analyzed the proposed NASA budget and come before the Congress to describe the impact of that budget proposal on the Nation's space science research enterprise. As members of the university community, our concern has been for the health of the sciences to which we are dedicated, and particularly for the continued strength of our universities, which play a unique and critical role in America's future in space. From our universities come many of the ideas which will shape that future, and our students are the people who will make that future a reality. And through our universities the great discoveries of the space program are transmitted to the next generation.

At our meeting last week, the mood of the Space Science Working Group was subdued. Well aware of the climate of severe budgetary restraint which pervades the Nation this year, we are grateful that the current budget proposal imposes no draconian cuts in NASA's space science programs. In past years we have felt that certain budget omissions would create severe immediate problems for the health of space sciences in the Nation. We have come to the Congress for help, and the Congress has responded.

This year. however. we see no immediate crisis which. In the present budgetary environment, would justify our asking for your help. This year we are resigned. if not content. to accept a budget which- if passed as it is proposed- is at least minimally adequate to continue programs already under way.

The NASA Space Science program, we concluded, is on a ballistic trajectory for 1986. Superficially this may sound good, but in reality it means the rocket engines have been shut off, and we are just coasting. We are constrained to follow a trajectory which was determined by our planning and actions in the past. With this budget proposal, nothing new enters the equation of our motion. And as long as no new energy or momentum is added to our projectile, its path will eventually come to be recognized for what it really is -- free fall. No matter that its present course looks ever upward. with several spectacular achievements expected in the coming year, including the Voyager fly-by of Uranus Shuttle and ground-based observations of Halley's Comet, the launch of the Galileo spacecraft to Jupiter, and the launch of the Hubble Space Telescope. We should be euphoric as we approach these new heights, and we are. At the same time, we must remember that there will be no new heights in the future unless we invest some resources now. Our Nation's space science enterprise is strong. and it can probably survive by coasting for a year, but it will require more energy next year if it is to avoid slipping into free fall.

The Space Science Working Group's concern results, of course, from the lack of any new starts for space science in the proposed budget for FY 1986. Normally, there have been one or more new science programs started every year, and these eventually grow in importance to replace other programs which are completed. Such new starts do not represent an expansion of our efforts, but simply provide the necessary momentum to keep the space sciences steadily advancing. When programs which have been brought to the stage of being ready for a new start are left dangling, as several are now, the progress of our whole space research enterprise is impeded, since Research & Analysis (R&A) funds which could have been used for other, new purposes are tied up supporting the waiting period of the new start candidates. If this waiting period is too long, the results can be disastrous, both for the projects not started and for all of the other activities which are slowed as a result.

Furthermore, the fierce competition which will tend to arise naturally next year or the year after among several new start candidates in different branches of space science is not a healthy situation. Competition is fine when we want to see who is best or strongest. But there is no objective way of assigning values to the different disciplines which make up the broad field of endeavor we call space science. We must, therefore, treat these various disciplines as we treat our children, and encourage them not to compete with each other, but to compete with themselves to become the best that they can be. It is usually best if your children are not all trying to get into the same college in the same year.

Our concern for the future health of the space sciences in this Nation does not end with the lack of a major new project start in the proposed budget. Another concern arises from the continuing lack of frequent, low-cost flight opportunities aboard the Space Shuttle. We believe that the importance of flight opportunities to the university space research community is not fully appreciated. Such opportunities give us the chance to take many small steps forward and to prepare for the leaps that the big programs provide. It is in these small. frequent projects that we can develop new ideas and new instruments and provide hands-on experience with space flight hardware for our students. It is also through such flight programs that many of us derive the most of the funding which helps to support the people. the activities, and the instrumentation in our laboratories. The last major solicitation of experiments for the Space Shuttle was conducted in 1978, and none of the experiments selected has yet been flown. I was fortunate enough to have had my experiment selected in that process, but when it is launched in 1986, I will have spent eight years preparing for it. This is only one year less than I will have spent on another project -- to develop an instrument for the Hubble Space Telescope. It is clear that the Shuttle has so far not provided the quick and easy access to space that is necessary for a productive space science program.

NASA is aware of this problem, and a recent report of the NASA Advisory Council's Shuttle Science Working Group reviews the situation and makes several recommendations. The Space Science Working Group strongly supports the findings and recommendations of that report, which includes an estimate that a healthy program of Shuttle-borne science will need about $25 million per year in the near future. If we are to effectively use the Space Station for science in the future, we must learn to use the Shuttle for science now. NASA needs a "frequent flyer program" in 1986 if it is to have many experienced and loyal passengers for the Space Station in 1996.

I would now like to turn to a theme which the Space Science Working Group has repeated each year. The big space programs which receive so much public attention stand on a broad base of scientific activities which are supported by the Research and Analysis Program in NASA. Without a firm foundation of Research & Analysis (R&A), the spectacular advances of which we are so justifiably proud would not be possible. The R&A programs support the formulation of new scientific questions to be asked, the early conceptualization of missions which can address those questions, the analysis of data from on-going and completed missions, and the development of theoretical understanding of the results obtained. This then leads back again to new scientific questions. It may seem sometimes as if we are simply going round in circles, but the path of our progress is better described by a helix. With each new turn we move to a higher plane in which the scientific questions become more profound, the missions become more challenging and expensive, the data analysis becomes more difficult, and the understanding we achieve grows deeper. This is the essence of the scientific enterprise. As we climb up the helix, the path becomes steeper, and we find we must work harder and invest more energy and resources to continue to advance. We cannot continue to reach these higher planes by coasting.

For some time now, the support for Research & Analysis programs in the space sciences has been steadily eroding. This is highlighted in the July 1984 Report of NASA's Space and Earth Science Advisory Committee on Research and Analysis in the Space and Earth Sciences published last year. The Space Science Working Group agrees with the findings and recommendations expressed in this report. We must begin soon to reverse this long-term trend if we are to maintain the health of our Nation's investment in the space sciences.

As I stated earlier, universities train the future generations of scientists and engineers. We must increase our support for students in the space sciences, or we will have no cadre to continue the achievements of our past. NASA recently established a new component of its Graduate Student Researchers Program which will provide financial support to graduate students studying in fields related to space science. We would like to acknowledge and commend this initiative. The program should be given continued support and permitted to grow.

We must find a way to improve the deteriorating state of the equipment and instrumentation in our university laboratories. With declining purchasing power of Research & Analysis funds, new equipment cannot be purchased. Much of the current research is being carried out. and the next generation of students is being trained, with equipment from a past generation. The need to upgrade university laboratory equipment has been recognized by the National Science Foundation and the Departments of Energy and Defense which have funded programs to address the needs. NASA should undertake a similar program as was recommended in the July 1983 Report of the NASA/University Relations Study Group.

It appears that this may not be a year in which to hope for substantial improvements in these long-term problems. But these are not problems which have developed overnight, or in one year, and they will not be solved in one year either. The requirements for addressing these long-term problems have been identified in the reports of several panels which I cited earlier. Each year that these problems are not addressed, they become more critical and difficult to solve. We are prepared to wait for another year and to watch our scientific enterprise coast for a little way, but we also clearly recognize that this cannot be allowed to continue for long. We urge NASA and the Congress to begin planning a solution now.

THE SPACE SCIENCE WORKING GROUP'S* STATEMENT ON THE FY 1986 NASA SPACE SCIENCE BUDGET

INTRODUCTION

NASA's space science programs are a source of great pride to the United States. They have brought this country worldwide recognition for its scientific and technological leadership. The unknown frontiers of space provide challenges to scientific inquiry which result in spectacular discoveries. These discoveries in turn stimulate the development of new technologies which strengthen our national security and increase our industrial productivity. Our future leadership and economic prosperity are dependent upon the vigor of our research and technological efforts today and NASA's space science programs are at the forefront of that effort.

Universities are and will continue to be a vital component of the United States space science program. University scientists perform basic space science research--they pose fundamental questions to be answered by NASA missions. In the process, university scientists train the succeeding generation of space scientists and engineers. The interaction at universities between scientists working in the space program and their colleagues in a variety of disciplines provides a source of new ideas for the NASA program and facilitates the incorporation of the space program's results into the mainstream of the nation's scientific and technological base.

SPACE SCIENCE IN THE PROPOSED BUDGET

The proposed budget for the Office of Space Science and Applications would continue the funding of several programs which will make 1986 an exceptional year for space science. 1986 will see the launches of Galileo to Jupiter, the International Ulysses mission to view, for the first time, the Sun from high heliospheric latitudes and the Hubble Space Telescope to conduct astronomical investigations never before possible from ground observatories. In addition. the Voyager 1 spacecraft will encounter Uranus on its trip out of the solar system and Halley's comet will be studied from ground and Shuttle-based telescopes.

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* The Space Science Working Group is a consortium of research universities whose members participate in NASA space science programs. For more information, contact the Association of American Universities, One Dupont Circle. N.W.. Suite 730, Washington, D.C. 20036, (202) 466-5030.

The growth in funding from FY 1985 is primarily due to planned increases to execute previously approved missions such as the Upper Atmospheric Research Satellite, the Mars Observer, and the Venus Radar Mapper. Increases in Mission Operations and Data Analysis (MO&DA) will prepare for the the soon-to-be-launched Hubble Space Telescope and provide for analysis of data from recent successful missions such as Earth Radiation Budget Experiment (ERBE) and Active Magnetospheric Particle Tracer Explorer (AMPTE). It is notable that for the first time in several years, NASA is proposing increases for all of the Research & Analysis budgets. These nominal increases will offset, in part, reductions in purchasing power due to inflation.

- The Lack Of New Starts

While the proposed budget will continue to fund those programs which are in place in the FY 1985 budget; it provides no new scientific mission starts. The lack of even one new start this year interrupts the orderly advance of the U.S. space science program and represents a curtailment in our national program. One important measure of the program's vigor is the rate of new starts, normally one or more in a given year.

"New start" status for a mission is a milestone in the orderly progression of a program. It occurs after the mission has been studied and planned by scientists and contractors. and in some cases, after teams of investigators have been selected. Already. the queue of science missions is backed up. with some high-priority projects having been deleted or postponed for years.

Much of the fundamental research conducted in NASA space science programs is linked budgetarily to space missions. Delays in funding can disrupt research and training far beyond the duration of those delays. Research teams--and the programs of research and graduate education they conduct--must be assembled carefully over time; once disrupted. they cannot easily be reassembled.

- The Proposed Budget Fails to Address the Needs of the Space Science Program Infrastructure

NASA's space missions, which receive so much public attention, stand on a broad infrastructure of scientific research and training activities conducted primarily at universities and NASA centers. The success of the missions depends greatly on the condition of these activities, which we note, have suffered a slow erosion over time. The proposed FY 1986 budget fails to address the structural deficiencies. These deficiencies--including growing obsolescence of laboratory and other research equipment and facilities, and inadequate support for graduate students, constitute an accumulating deficit. Once that structural deficit falls below a certain critical mass, our capacity to respond to new challenges is severely weakened. We are rapidly approaching that point.

The Space Science Working Group is extremely concerned that the Administration's FY 1986 budget for NASA reflects short-term budgetary decisions that may generate unintended but irreversible policy consequences for U.S. leadership in space science. While the proposal does not present an immediate crisis, it is another budget which fails to address the basic structural needs thus continuing the slow erosion of the space science research base.

The following paragraphs describe four fundamental aspects of the NASA research base program which are in need of substantial strengthening over time.

FREQUENT, LOW-COST FLIGHT OPPORTUNITIES: The development of new instrumentation for NASA's programs and the training of students require frequent, low-cost flight opportunities. New instruments need to be tested on short Shuttle flights and on suborbital flights before being placed on expensive, long-duration missions. Graduate students need the "hands-on" experience of designing, building, and flying a low-cost payload. In addition to the essential education. these flights produce significant results which sharpen the scientific questions to be answered in major spaceflight programs.

The Shuttle is supposed to provide frequent flight opportunities through "get-away specials," "hitchhikers," and free-flying Spartans. However, this aspect of the Shuttle program has yet to be fully realized. The NASA Advisory Council Shuttle Science Working Group Report (September. 1984), identifies further steps that are necessary to increase and simplify flight opportunities for science and technology on the Shuttle.

Aircraft, sounding rockets, and balloons in the suborbital program provide low-cost, low-risk. and quick-turnaround flight opportunities. This program has been a mainstay of instrument development and graduate student participation in the space program since its inception and will continue in this role for the foreseeable future. The suborbital program is a low-cost, high-leverage component of the NASA effort which should receive continuing support.

RESEARCH LABORATORY EQUIPMENT: Much university laboratory equipment for space research is out of date. With declining purchasing power of Research and Analysis funds, new equipment cannot be purchased. Much current research and graduate students' training is being conducted with equipment from a past generation impairing the quality and productivity of research and training programs.

The need to upgrade university laboratory equipment has been recognized by the National Science Foundation and the Departments of Energy and Defense, which have initiated targeted programs to address the needs. NASA should undertake a similar program, as was recommended in the Report of the NASA/University Relations Study Group (July, 1983).

GRADUATE EDUCATION: Universities train the future generations of scientists and engineers--the talent that will provide the new ideas in space research and will apply the knowledge generated by that research to problems in other technological fields. NASA has recently established a new component of its Graduate Student Researchers Program which will provide financial support to graduate students at universities studying in fields relating to space science. We commend NASA for this promising effort to attract the best students to pursue careers in space science. We urge NASA to expand the program to support the increasing numbers of talented students needed for future challenges.

RESEARCH AND ANALYSIS: NASA's Research and Analysis programs provide the underpinning for all space research at universities. These programs support the development of new instruments and mission concepts. the analysis of data from ongoing missions, the analysis of data from completed missions. the development of theoretical ideas and models, and the education of graduate students. The July 1984 Report of NASA's Space and Earth Science Advisory Committee on Research and Analysis in Space and Earth Sciences said, "It cannot be emphasized too strongly that the quality of NASA's scientific program and the return that the country receives from its investment in space missions, directly depends upon the effectiveness, the health, and the vitality of the Research and Analysis Program."

The funding for Research and Analysis has not kept pace with inflation, nor with the growing breadth of scientific disciplines involved in the space program. Indeed, a recent analysis by the NASA Space and Earth Sciences Advisory Committee reveals a steady decline, in adjusted dollars, of about 3% per year in space science R&A programs since the late 1960's. The Research and Analysis portion of the budget for the Office of Space Science and Applications must be funded to recover some of this loss and to provide real growth in the level of research. Research and Analysis activities should be given a priority commensurate with that of the flight programs.

SOLUTIONS TO THE LONG-TERM PROBLEMS

Several panels have issued recommendations for addressing these long-term problems.

--The Space and Earth Sciences Advisory Committee has recommended a $30M increase in Research & Analysis to alleviate the problems in these program areas.

--The July 1983 Report of the NASA-University Relations Study Group states that an $11M annual budget is required to upgrade university laboratory equipment. That same report recommends that NASA initiate a graduate fellowship program that will grow after four years to support 200 students. The cost of this program would be approximately $4M per year. (As indicated above, NASA started a new component of its Graduate Student Researchers program in FY 1985, which responds in part of this recommendation.)

--The NASA Advisory Council Shuttle Science Working Group Report (September, 1984), recommends a sustained program of $25M a year to provide essential, frequent flight opportunities on Shuttle. NASA representatives have stated that the proposed FY 1986 budget includes about $3M for this purpose.

CONCLUSION

The Space Science Working Group, is seriously concerned about the long-term effects of these short-term budgetary decisions on the research and training capability of our space science programs. The continuing erosion in U.S. basic space science research represents a loss of investment in our nation's future. Scientific programs and the highly-trained cadre of scientists, which we believe to be important to the future of our nation, take many years to build.

We realize that current fiscal axigencies may require that any solutions to these problems be postponed until after FY 1986. However, we do not believe that it is wise to wait until a crisis is fully upon us before taking corrective measures; by then it will take many years to recover. We urge NASA and the Congress to consider these fundamental deficiencies in the budget, and to begin planning a long-term solution now.

Appendix: Analysis of the Proposed FY 1986 NASA Space Science Budget

January, 1985

ISSUES OF IMPORTANCE FOR SPACE RESEARCH AT UNIVERSITIES

Universities are and will continue to be a vital component of the United States space science program. University scientists perform basic space science research--they pose scientific questions which can only be answered by NASA missions, develop and build instruments, analyze data, and develop new theoretical models. Universities train the next generation of space scientists and engineers. The interaction at universities between scientists who are in the space program and those who are not 1) provides a source of new ideas for the NASA program and 2) speeds the incorporation of the space program's results into the mainstream of the nation's scientific and technological base.

The Space Science Working Group of the Association of American Universities considers the following issues of particular importance for the continued vitality of space research at universities:

RESEARCH AND ANALYSIS: NASA's Research and Analysis (R&A) programs provide the underpinning for all space research at universities. These programs support the development of new instruments and mission concepts, the analysis of data from ongoing missions, the analysis of data from completed missions, the development of theoretical models, and the education of graduate students. The July 1984 Report of NASA's Space and Earth Science Advisory Committee on Research and Analysis in Space and Earth Sciences said, "It cannot be emphasized too strongly that the quality of NASA's scientific program and the return that the country receives from its investment in space missions, directly depends on the effectiveness, the health, and the vitality of the Research and Analysis Program."

The funding for Research and Analysis has eroded in recent years. Budget increases have been consistently less than inflation, and in some cases actual funding decreases have occurred.

The Research and Analysis portion of the budget of the Office of Space Science and Applications should be funded to provide a continuing and growing level of support for university research activities. Increases to cover inflation should be provided. In areas where decreases in funding have occurred, university activities should be restored to their previous level. Research and Analysis activities should be given a priority commensurate with that of flight programs.

GRADUATE EDUCATION: Universities train the next generation of scientists and engineers--the talent that will provide the new ideas in space research; the talent that will apply their training in space research to the problems in other technological fields.

NASA has recently established a new component of its Graduate Student Researchers Program which will provide financial support to graduate students at universities studying in fields related to space science. This program is important because it will attract the best students to pursue careers in space science; it should be given continued support and permitted to grow.

RESEARCH LABORATORY EQUIPMENT: University laboratory equipment for space research is out of date. With the declining purchasing power of Research and Analysis funds, new equipment cannot be purchased. The next generation of students is being trained with equipment from a past generation.

The need to upgrade university laboratory equipment has been recognized by the National Science Foundation and the Departments of Energy and Defense which have established programs to meet those needs. NASA should be funded to undertake a similar program to upgrade university space research equipment. In particular, the recommendation of the NASA/University Relations Study Group (July, 1983) that $11M be added to the budget of the Office of Space Science and Applications for the purchase of university laboratory equipment would be an important start on such a program.

FREQUENT, LOW-COST FLIGHT OPPORTUNITIES: The development of new instrumentation for NASA's programs and the training of students require frequent, low-cost flight opportunities. New instruments need to be tested on short Shuttle flights and on suborbital flights, before being placed on expensive, long-duration missions. Graduate students need the "hands-on" experience of designing, building, and then flying a low-cost payload during the short term of a graduate education career.

The Shuttle is supposed to provide frequent flight opportunities through "get-away specials," "hitchhikers," and free-flying Spartans. However, this potential of the Shuttle program has yet to be fully realized. As was reported by the NASA Advisory Council Shuttle Science Working Group, further steps are necessary to increase and simplify flight opportunities for science and technology on the Shuttle.

Aircraft, sounding rockets, and balloons in the suborbital program provide low-cost, low-risk, and quick-turnaround flight opportunities. This program has been the mainstay of instrument development and graduate student participation in the space program since its inception, and will continue in this role for the foreseeable future. The suborbital program is a low cost, high leverage component of the NASA effort which should receive continuing support.

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APPENDIX: ANALYSIS OF PROPOSED FY 1986 NASA SPACE SCIENCE BUDGET

PHYSICS AND ASTRONOMY

The overall Physics and Astronomy budget of $630.4M decreases by $46.8M from the FY 1985 level. This is due to the planned decrease in funding for the two major observatory programs. Hubble Space Telescope (HST) and Gamma Ray Observatory (GRO), which are now past their peak development phase and are nearing launch (in 1986 and 1988, respectively). The combined decrease for these two programs is $97.1M so that the remaining portions of the Physics and Astronomy budget have increased by $50.3M, which is approximately a 7% increase over FY 1985. The largest part of this increase is for two projects: the Solar Optical Telescope (SOT) ($20.2M). and for HST instrument refurbishment and operations ($13.3M increase). Thus the bulk of the Physics and Astronomy program remains at funding levels which are nearly constant, or at most increased by inflation, from their FY 1985 levels. The following paragraphs summarize the proposed budget for the remaining parts of the Physics and Astronomy program; a budget table is included on pages 6-7.

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT: These programs are increased by $9.9M over their FY 1985 values in addition to a $20M increase for the previously approved Solar Optical Telescope. Two major Shuttle flight programs are planned for FY 1986: the ASTRO-1 mission for March 1986. and Spacelab 3 to fly later in the year. Other Shuttle missions are under development, and it is expected that a portion of the budget increase in this area will respond to the need by the scientific community for a substantially increased program of low-cost Shuttle experiment opportunities such as represented by the Spartan program.

EXPLORER DEVELOPMENT: These programs are increased $3.3M, which is 6% over their FY 1985 values. This will support continued development on two US Explorer-class missions: COBE for cosmic microwave background studies, and EUVE for extreme ultraviolet observations. NASA will deliver a high resolution x-ray detector to be included on the German x-ray telescope ROSAT scheduled for a shuttle launch in 1987. A re-flight of the Long Duration Exposure Facility (LDEF) for cosmic ray studies is also planned for 1986. No new starts in the Explorer program are planned for FY 1986 although definition studies will continue on possible future Explorers such as the X-Ray Timing Explorer (XTE) and the Far Ultraviolet Spectroscopy Explorer (FUSE).

MISSION OPERATIONS AND DATA ANALYSIS: These programs are increased by $10.8M over their FY 1985 values. largely for increased costs for HST as the launch date in 1986 approaches. Much of this increase is for the development of second generation instruments for HST. The extended mission for the Solar Maximum Mission (SMM) also accounts for a $2.8M increase, while support for the High Energy Astronomy Observatory (HEAO) and Explorer data analysis programs is decreased.

RESEARCH AND ANALYSIS (R&A): This budget is increased by $2.4M over FY 1985, a 6% increase that is essentially constant funding in real dollars. The modest increase in the R&A line is welcome but will be absorbed largely by the definition studies for the Gravity Probe-B mission. The new Astrophysics theory program initiated last year will be maintained at the current level. The Advanced Technology Development (ATD) program will provide minimal support for the definition and design studies for the highest priority candidate future astrophysics observatory missions, the Advanced X-Ray Astrophysics Facility (AXAF) and the Space Infrared Telescope Facility (SIRTF). Both missions have gone through the instrument selection phase but low funding levels are presently only sufficient for Phase B definition studies for AXAF.

SUBORBITAL PROGRAMS: These programs, vital for the development of future space missions. are increased by $3.7M. or approximately for inflation. The anticipated number of balloon flights will be increased. and the sounding rocket program will continue to be phased into the Spartan program with two new Spartan experiment development efforts to be initiated.

PLANETARY EXPLORATION

The requested Planetary Exploration budget of $359M represents a continuation of ongoing programs that were started in previous years, with no new initiatives or program augmentations. The increase of $68.1M over the FY 1985 budget results largely from the normal spending histories of mission projects, which reach peak spending levels several years after a project starts. The major budget changes from last year are in the Venus Radar Mapper (VRM) and the Mars Observer (MGCO), both of which are approaching peak spending years. Galileo development is diminishing as it and approaches launch in 1986. Increases in the Mission Operations and Data Analysis (MO&DA) line largely reflect the preparation of the Voyager mission for the Neptune encounter as well as the start of Galileo mission operations. The Planetary Research and Analysis program continues at approximately constant dollars. which is a 4% decrease adjusted for nominal inflation.

The requested budget is a gratifying reflection of the Administration's commitment to rebuild the U.S. Planetary Exploration program back to a vigorous level. This is particularly evident in Research and Analysis (R&A). The proposed R&A

budget is a welcome change from recent crisis years, in each of which substantial decreases were proposed; this year R&A will suffer a modest decrease due to inflation.

The following paragraphs briefly analyze the various major parts of the Planetary Exploration budget, their condition in the proposed budget, and the contributions that these programs make to the nation's overall space science effort.

GALILEO DEVELOPMENT: This project shows a decrease of $16.4M as the development stage draws to completion. Galileo was originally to be launched in 1982, but was delayed four years by development problems, including the absence of an adequate shuttle-based launch capability. The implementation of the Galileo mission to Jupiter marks the start of a new and intensive phase of outer-planets investigation.

VENUS RADAR MAPPER: The Venus Radar Mapper (VRM) increases $19.5M as it enters the third year of development. Due to be launched in 1988, VRM will carry out a detailed geological mapping of Venus' surface. This is an essential step in NASA's detailed study of the triad of terrestrial planets: Venus, Earth, and Mars. Knowledge obtained through these investigations will greatly advance our understanding of the behavior and evolution of terrestrial planets, including Earth.

MARS OBSERVER: The Mars Geochemical and Climatological Orbiter is the first in the sequence of "Observers", a class of relatively low-cost, frequently-launched planetary spacecraft that forms part of the core of the ongoing NASA planetary exploration program. The $30.8M increase in this line reflects continuation of an orderly and controlled development sequence for this mission. This mission will carry out important global investigations of Mars, and is part of the detailed study of the triad of terrestrial planets.

ULYSSES (ISPM): The International Solar-Polar Mission is a "non-planetary" project which is being managed by the NASA planetary division in order to capitalize on the deep-space operations expertise which is unique to that division. Ulysses is being carried out in collaboration with the European Space Agency; it will be the first spacecraft to carry scientific instruments to high heliospheric latitudes, well away from the ecliptic plane, and will make measurements critical to our understanding of the three-dimensional structure of interplanetary space. The $3.4M decrease in that line follows the expected evolution of that project.

MISSION OPERATIONS AND DATA ANALYSIS (MO&DA): This line supports the in-flight operation and data analysis of ongoing planetary missions. The increase of $36.2M reflects the activities needed to accommodate the Voyager encounters with Uranus and Neptune, the onset of Galileo operations, and the other continuing mission operations. Including Pioneer and Ulysses. The MO&DA activity is a basic part of the infrastructure needed to support deep-space missions and other planetary projects.

RESEARCH AND ANALYSIS (R&A): This R&A program supports basic research activities in planetary science as well as research and development, and program activities needed to plan future projects. It is from this budget line that the broad planetary research activities are supported in the nation's universities and laboratories. The proposed budget increase of $1.4M is about 2.3%, well below the recently increased costs of carrying out these activities.

ENVIRONMENTAL AND SOLID EARTH OBSERVATIONS PROGRAMS

The Environmental and Solid Earth Observations programs have a number of positive features in the proposed FY 1986 budget. It is gratifying to see that the Upper Atmosphere Research Satellite Mission and the Scatterometer development programs follow their nominal timelines. Inflationary increases are provided for each of the Research and Analysis lines, and indeed in the case of R&A for Solid Earth Observations an augmentation of $4.5M (28%) is proposed. Although no further erosion has occurred this year, it should be noted that some of these R&A lines have still not been returned to funding levels of previous years. A substantial increase is also proposed for Mission Operations & Data Analysis (MO&DA) to accommodate recent successful flight missions such as the Active Magnetospheric Particle Tracer Explorer (AMPTE). Ongoing Shuttle payloads will proceed on schedule with the proposed funding.

SOLID EARTH OBSERVATIONS

The Solid Earth Observations program is budgeted at $74.9M, an increase of $17.3M or 30% over the FY 1985 level. Much of this increase is in the Shuttle/Spacelab payloads line and will go toward advanced spectrometer technology development and study of the next generation of Shuttle Imaging Radar (SIR-C). The Geodynamics Program. Including the Crustal Dynamics project, laser network operations, and research and technique development, is budgeted at 6% over FY 1985, an inflationary increase. The R&A line which supports land remote sensing is increased by 29%, a much needed supplement. This area has long been recognized as being one where NASA needs to develop a stronger scientific base.

ENVIRONMENTAL OBSERVATIONS

The Environmental Observations program is budgeted at $317.5M. an increase of 30% over FY 1985 that reflects the expected growth in the Upper Atmosphere Research Satellite and Scatterometer programs. The R&A lines show modest growth of approximately 6% reflecting inflation over the year. Extended mission operations show a modest growth to accommodate the operations and data analysis of recent successful flight missions such as Nimbus-7, the Solar Mesosphere Explorer (SME), and the International Sun-Earth Explorers. The Tethered Satellite Payloads line shows $15M growth in anticipation of instrument development following the initial payload selection.

The principal difficulty for this program area is the lack of new starts. The Space and Earth Science Advisory Committee recommended two new starts in FY 1986, the Ocean Topography Experiment (TOPEX) and the International Solar Terrestrial Program (ISTP), and neither were included in the proposed budget. The problem is compounded by inadequate Advanced Technology Development (ATD) funds for these programs, which will make the orderly study of these missions and the maintenance of their scientific teams difficult. TOPEX's ATD will be funded in the Oceanic Processes Research and Analysis line and ISTP's in the Space Physics Research and Analysis line.

SPACE SCIENCE IN THE FY 1986 NASA BUDGET
(in millions of dollars)

	1982	a/ 1983	1984	1985	Proposed 1986
Total NASA	6020.0	6836.4	7217.5	7510.7	7886.0
Total Research & Development	4772.0	1902.5	2028.5	2422.6	2881.8
Space Flight, Control and Data Communications		3633.0	3775.3	3601.8	3509.9
Total Space Science & Applications	896.2	1034.1	1157.0	1404.5	1613.2
Space Station	-	-	(21.9)	150.0	230.0
Total Physics & Astronomy	322.4	470.3	567.6	677.2	630.4
Space Telescope Development	121.5	182.5	195.6	195.0	127.8
Gamma Ray Observatory	8.0	34.5	85.9	117.2	87.3
Shuttle/Spacelab	47.6	81.0	80.9	105.4	135.5
Explorer Development	33.3	34.3	48.7	51.9	55.2
Mission Operations & Data Analysis	45.3	61.4	68.1	109.1	119.9
Research & Analysis	22.9	28.5	35.8	39.9	42.3
Suborbital	43.8	48.1	52.3	58.7	62.4
Total Planetary Exploration	210.0	186.4	217.4	290.9	359.0
Galileo	115.7	91.6	79.5	56.1	39.7
Venus Radar Mapper	-	-	29.0	92.5	112.0
International Solar Polar	5.0	6.0	6.0	9.0	5.6
Mars Geoscience/ Climatology Orbiter		-	-	13.0	43.8
Mission Operations & Data Analysis	42.6	38.5	43.4	58.8	95.0
Research & Analysis	46.7	50.3	59.5	61.5	62.9
Total Life Sciences	39.5	55.7	58.0	62.3	72.0
Flight Experiments	14.0	24.0	23.0	27.1	33.4
Research & Analysis	25.5	31.7	35.0	35.2	38.6
Total Solid Earth Observations	149.4	128.9	76.4	57.6	74.9
Landsat-4	81.9	58.4	16.8	-	-
Shuttle/Spacelab	12.3	14.5	17.0	12.1	23.1
Geodynamics	22.9	28.1	28.0	29.9	31.7
Research & Analysis	15.5	11.8	14.6	15.6	20.1

SPACE SCIENCE IN THE FY 1986 NASA BUDGET (continued)
(in millions of dollars)

	1982	1983	1984	1985	Proposed 1986
Total Environmental Observations	133.0	156.9	162.0	212.7	317.5
Total Research & Analysis	71.8	86.4	90.8	95.6	101.7
Upper Atmosphere	20.5	27.7	28.4	31.0	33.0
Atmosphere dynamics and Radiation R&A	22.3	26.5	27.4	28.5	30.3
Ocean processes	16.9	17.0	18.2	19.4	20.6
Space Physics	12.1	15.2	16.8	16.7	17.8
Shuttle/Spacelab	4.1	3.7	7.6	7.8	5.6
Operational Sat. Improv.	6.0	6.0	0.6	-	-
Earth radiation budget	24.0	24.0	15.5	8.1	2.0
Extended mission ops	16.1	22.8	27.4	29.5	37.0
Interdisciplinary R&A	-	-	-	1.0	1.0
Tethered Satellite Payloads	-	-	-	3.0	4.5
Scatterometer	-	-	-	12.0	31.7
Upper Atmos Research Satel.	6.0	14.0	20.0	55.7	134.0

a/ Shown on a comparative basis with the budget structure changes instituted in FY 1984.

Mr. NELSON. Thank you, Dr. Davidsen.

Dr. Donahue, you had said that the science community has difficulty in setting priorities across disciplines.

Dr. Davidsen, you just said, "The fierce competition which will tend to arise naturally next year or the year after among several start candidates is not a healthy situation."

Now, when we have a crunch that we obviously are going to have, then how do we set the priorities? We would like some advice from you. Do you, in the scientific community, want us in Congress to do it, or what is the "democratic process" that Dr. Donahue, you mentioned? Why don't all three of you share your ideas with us on that.

Dr. DONAHUE. Simultaneously?

The democratic process—well, let me back off. I think that in the past the question of which mission should come next has generally been solved by everybody standing in line and taking its turn. As I look ahead at the new start candidates, and I was counting about eight of them standing in line in the Earth sciences and relativity, space plasma physics, x-ray astronomy and in geosciences, all of the disciplines are represented there, and our real problem is to get all of these going, as I said, in something like the next 5 years. If we could get 1½ to 2 new starts a year, we would have it done.

I don't think that we really face a serious problem of various disciplines clawing at each other if you start in a reasonable order, with each discipline having its turn, and proceed to get everything underway. This is the way in the past this worked, and I don't see why it can't work in the future that way.

Dr. **Lanzerotti**. As I indicated, SESAC is attempting to address this question, and I would certainly be premature and out of line to indicate what, if anything, new they will ever have to say on the question of priority across disciplines other than within the disciplines themselves. So I won't try at this point, but I think SESAC, as part of its programmatic responsibility, is trying to address this so that the scientific community itself may be able to say something about it and not allow it to be only a political football and who speaks loudest, speaks first or arrives first.

With regard to the immediate situation, I would have to second what Professor Donahue has just indicated. I think with regard to this possibly a year situation, even though there is a coalescing, as I indicated, as that does cause a ripple effect, as my testimony indicates, I would say, personally, that the prioritization, there is nothing that I see now that would change the priority of what SESAC established last year being slid by 1 year. Personally that is what I would state. I do not see that that would affect the United States stance in space science.

I am ignoring the political reality of foreign participation and competition, but with just regarding how we would proceed within this Nation, I think that sliding things by one year would be OK, and one would perceive that the same type of priorities that SESAC had established and the science community had sensibly brought forward. Beyond 1 year, though, I am not sure how I would answer that now.

I do agree with Tom Donahue in that one-and-a-half to two new starts per year, if that were possible beginning next year, the situation of priorities would not probably arise.

Dr. **Donahue**. If we drop down to a level of, let us say, in the next 5 years only three new starts, then we are in such a mess that I don't think there is any logical way or any reasonable way to determine which discipline comes first.

Dr. **Lanzerotti**. I think then if that were the case in the Nation, we would have to decide that there are some areas of space science that we would not participate in nationally. Whether it would be solar and space physics, we would just decide not to do solar physics in the United States any more for a decade, or space plasma physics, and we nearly decided not to do space planetary exploration at one time. If that were the case, where there were only two or three new starts over 5, 6, or 7 years, then I think we would have to make a conscious decision, and that would be a science decision, as well as a political decision.

Mr. **Nelson**. Dr. Davidsen.

Dr. **Davidsen**. The Space Science Working Group represents astronomers and space plasma physicists and planetary scientists and the whole range of interests in the space sciences, and we have a great difficulty, indeed an impossible time, to agree on priorities between these various programs because we all have a great affection for our own particular disciplines, and we can argue the case for any of those programs that fall within our own area of expertise, but generally we find it pretty hard.

So I am not too sanguine about the possibility that we in the science community, at least at the level of the group that I represent now, could possibly prioritize between things.

Referring back to my analogy of a moment ago, I think we might consider just sending the oldest kid to college first. That seems reasonable, but, of course, if we wait long enough, he will get so old that he doesn't need college any more, and that is not going to be a reasonable way to proceed either.

So, I think the point is that if we are to have a healthy program in space sciences, and that means lots of different disciplines, we have to be willing to support them all, and they all have to proceed independently of each other, not in competition with each other, to progress at a rate that is reasonable for that scientific discipline.

All of them have new start candidates every year. They don't all need one every year, but they need one every 2 or 3 years at least to be viable.

Mr. Nelson. Thank you all very much.

Mr. Brown.

Mr. Brown. Gentlemen, I need some numbers to kind of fix what we are talking about here. You have indicated that one-and-a-half or two new starts a year would be a much more comfortable situation. What does this mean in terms of the amount required to get started on Topex or ISTP or gravity probe B? What are the numbers that we are talking about in some rough way?

Dr. Donahue. Well, to get GPB going forward, a shuttle test, you ought to have something like $10 million. I don't remember whether it is $10 million, but it is in that ballpark. Topex, I think, would have required about $20 million, and it is hard to put a figure on ISTP. You can start it for anything between $30 and $70 or $80 million.

I think what ISTP, given the fact that it is really an international program, what it would benefit from is some kind of a commitment that can be made for a reasonably small initial expenditure of a few million dollars, $5 or $6 or $7 million that would be an affirmation to our colleagues in Japan and Europe that the United States is serious about this mission and intends to go ahead.

But I am not in the programmatic business at NASA, but I think the numbers I have given you are probably in the ballpark for fiscal year 1986. I am sure of it.

Mr. Brown. Dr. Donahue, you referred to the longer range study that you are making on page 5 of your testimony 20 years after 1995. In effect, you are charting a course for the next 20 to 30 years in space science. Of course, this committee has long urged the need for some long-range planning in all aspects of the space program. We have a commission set up to look at that problem.

And my question is, how does the work that you are doing with regard to the science community fit into or coordinate with the work that the commission might be doing in terms of developing a strategic plan for the space program in general?

Dr. Donahue. Well, we are waiting, as I am sure you are, to see that commission put in place eagerly, and much of the planning in the plan with regard to the timing of that study is directed toward being in a position to brief that commission as soon as it begins its studies. So we have asked all of these task groups, and they have responded, to give us interim reports. We have those interim reports in hand, and I hope that we will be asked to interact then with that study as soon as it gets going.

I hope then that they won't have to go over the same ground that we have gone over. If they are willing to take our input, then we should be able to save them a great deal of work.

But the point is that as far as science is concerned, they would probably be drawing on the same group of people that we are for planning. We think that we have done a lot of the work for them as far as space is concerned.

Mr. **Brown**. Just looking at the problem of long-range planning from the perspective of science programs, what degree of confidence do you have—and I don't know how you quantify this, the plans that you would make today for, say, the next 25 years would be politically realistic. Do you think we could adhere to that kind of a program? The only place I know of where we do that kind of planning with any degree of validity is in the field of forest management, where it takes 40 years for a tree to grow, and we can pretty well figure what the problems will be over that period of time.

Dr. **Donahue**. Well, I was expecting you to ask me whether that plan would have scientific validity? I was a little surprised when you said political.

Mr. **Brown**. Well, they are not inseparable.

Dr. **Donahue**. Well, it is, I think, an unfortunate truth that, in fact, our science missions have gotten so complex, some of them, and the machinery of getting them flown is so intricate that it is taking us 10 years now between conception and launch of a mission if we are lucky, so that getting ready for 1995, we are none too early. I wish we were and that we could.

What I am a little concerned about is that we won't—I am more than a little concerned that we won't have all the missions that we have studied already flown by the turn of the century. I am afraid that we won't. But whenever it is that the present set of missions is completed, that is when the clock starts for this new study that we are doing, and I have a fair amount of confidence that we understand where we are when we start at the beginning.

But to predict what kind of interferometer we will be launching in the year 2013 is something none of us realistically think that we can project. But we have learned already that we can put together a program that has a lot of coherence and seems to make sense at this point. We may have to change on the basis of things that we learn between now and then, and certainly the confidence level drops as we go further and further into the future.

Mr. **Brown**. Just one additional question. You make some reference in the concluding page of your remarks about the use of detailees from universities at NASA similar to what NSF does. Are you referring to what they call rotators sometime, people coming in for a couple of years and going back to the university?

Dr. **Donahue**. Yes, sir.

Mr. **Brown**. And do you think that the universities cooperate and supply the person of the proper quality that would leave an academic career for that length of time?

Dr. **Donahue**. I am very confident that they based on the experience of National Science Foundation where that system is in place and works very well, at least in the disciplines that I am acquainted with. So it is something that you can't ask someone who doesn't have tenure to do, but a person who is fairly well established at the university finds that 2-year stint a very stimulating thing, and it is mutually beneficial where the National Science Foundation of the university are concerned, and, hence, I think that augers well for the system if NASA decides to go ahead.

Dr. **Lanzerotti**. May I comment? We discussed that at some length in the SESAC meeting yesterday, and SESAC has prepared a draft paper that we will present to NASA giving some of the strengths of the program and reasons for why people may want to take the position. And this will be circulated, once SESAC passes this, be circulated rather widely throughout the university community, sort of a white paper on this program as part of our programmatic responsibilities.

Mr. **Brown**. Thank you very much, sir.

Mr. **Nelson**. Mr. Volkmer.

Mr. **Volkmer**. No questions. Mr. Brown has covered things pretty well.

Mr. **Nelson**. Mr. Smith.

Mr. **Smith**. Dr. Davidsen, on page 6, you indicate that for some time now the support for research and analysis programs for sciences has been steadily eroding. Can you define support? I understand governmental support. What about other support within the scientific community, in the academic community, private sector? What is your point here, other than that we should be doing more in terms of the U.S. Government?

Dr. **Davidsen**. Yes, Mr. Smith. The support for the space sciences comes, I think it is fair to say, almost entirely from the Federal Government in terms of the money that is available to carry out this work. Of course, there is tremendous support from the entire Nation really in terms of interest in the things that are done, but there is very little money coming in from private foundations or this sort of thing, individual contributions, that really carries out any of the work we do. So we are talking about NASA funding really to carry on the work that prepares us for the major NASA missions that occurred.

Mr. **Smith**. I think one of the frustrating things we talk about, one of you mentioned, and I am not sure who it was, political versus scientific decision in terms of we as a committee, obviously we are sitting here in a political situation in a sense that we have to cast votes which affect your budget, the budgets within the space program, we know that. We are not scientists, most of us. We try to make political and scientific decisions based on the input from the scientific community, which is obviously why you are here.

But it is frustrating. I just look at, for example, just the approximately $200 million increase in the Office of Space and Science Application, and then I am a supporter of this type of appropriation. That is why I am here, and it is just frustrating to see you go down the list, and we have got all the categories here in space science and applications, and you see increases down the line.

And I don't want to put you on the spot, and I am not going to try to say who should or who shouldn't be funded, but where are we not doing the job? Do you need $200 million more or more than that, or are you saying that we are not prioritizing properly? I know the chairman asked earlier yesterday about priorities, but if you could be more specific on that, it would certainly help me.

I am concerned about this. I don't want to make my question too long, but even in the days of Sputnik, then there was a flat push to catch up, if you will. Well, I think we have caught up and made tremendous progress, and I don't want to see us fall backward either. I am concerned about the remarks that maybe we are falling backwards. If we are, is it because we are not appropriating enough money, or are we trying to do too much at the same time? What do you see as the problem?

Dr. **Davidsen**. That is a long and difficult question to deal with, Mr. Smith.

Mr. **Smith**. I know that.

Dr. **Davidsen**. The level, and I am speaking for the university space science community now, which is one part of the community of people that are interested in space sciences, of course. The level that we are lacking, I think when we talk about the erosion of the research and analysis funds, is nowhere near hundreds of millions of dollars. I believe the decline over the last 8 to 10 years or so has been on the order of $50 million. I think we have come down from something like a $200 million level to a $150 million level in recent dollars, 1982, 1983 dollars, something like that.

So, we had a healthy program, and it has just been slowly drifting downward, and we would like to see some effort to reverse that, but that is the order of magnitude of it.

I would also like to correct something I said a minute ago, that there is not all that much private support for what we are doing. In fact, if I think about my own university, for example, and this is true of others, there is really a lot of university money going into the space science research activity that goes on. Faculty members, myself and my colleagues, typically are getting 75 percent of their salaries from their universities, and some support, at least for the activities in their laboratories, and they are, at most, collecting perhaps this remaining 25 percent from contracts or grants that they have through NASA or the other funding agencies, and they spend far more than 25 percent of their time and energy on the Nation's scientific research enterprise. So, there is a contribution in kind on the part of the universities directly I think.

Dr. **Donahue**. May I add a remark responding to your question about what level of program would we consider to be adequate?

Mr. **Nelson**. Yes, sir.

Dr. **Donahue**. I think we are in agreement that the budget that you are being asked to authorize is really, I think, a good healthy budget in all respects, except as I said in the failure to start new missions. And in my response to Congressman Brown, I indicated that something like $30 million is about what you need to get some new starts this year, in fiscal year 1986.

But, of course, that has implications for the outyears where the spending in each of those missions increases. But at the same time, the rate of spending for other missions that have improved declines, and I would be talking off the top of my head to say what level we would find ourselves at in 3 or 4 years if we had the new starts. But it wouldn't be a level that is very much greater than the one at which we are operating today. It is something that I measure in tens of millions of dollars more rather than hundreds of millions of dollars.

What we are going to do by pushing all these starts together, if we try to start them in rapid order, however, is run the peak spending up to intolerably high levels.

Mr. **Nelson**. Mrs. Meyers.

Mrs. **Meyers**. No questions.

Mr. **Nelson**. Mr. Slaughter.

Mr. **Slaughter**. No questions.

Mr. **Nelson**. Mr. Walker.

Mr. **Walker**. Thank you, Mr. Chairman.

Dr. Donahue, if I understood you correctly, what you are concerned about is if we reached the mid-1990's, that we could have a point where we would have so many things in the pipeline that we can't possibly fly them all? Is that an accurate characterization of what one of your concerns is?

Dr. **Donahue**. Yes. The effect of postponing, say, two new starts from fiscal year 1986 to fiscal year 1987 and attempting to do the others in the time period originally planned would be to run the maximum rate of spending up to a level that we would be hard pressed to afford.

Mr. **Walker**. Did I also understand you to say that you are concerned that the ones that we have already committed ourselves to study for may not be flown before the end of the century?

Dr. **Donahue**. I am not talking about those missions that have already been authorized. They are progressing in an orderly fashion, but the number of missions that have been studied, that have been identified by the planning process that goes on in the Space Science Board and in SESAC, that number is quite large, and it is measured in something like 30 or 40, I think, if you total all of them up. All of them are valid missions.

Mr. **Walker**. And those are missions that have not necessarily been included in any of NASA's authorization plans at this point. Some of those constitute new starts, is that correct?

Dr. **Donahue**. Yes, they would constitute new starts. They are certainly in the 5-year plan.

Mr. **Walker**. Would there be any merit at all, looking at it from the scientific community, not only looking at the new starts but looking at a different concept as to how we fly some of those missions? If, for example, we are concerned about the capacity to fly missions in the mid-1990's aboard shuttle, would there be any merit in taking a look at the possibility of using privately-owned ELV's as a means for flying some of these missions in the future?

Dr. **Donahue**. I don't see what harm it could be. I will probably walk into a mine field here. I don't see why just having a look at something like that would do any harm.

As far as we are concerned in space science, the more launch vehicles available, the better.

Mr. **Walker**. Well, let me take it one step further, though.

For example, some of you are from the university community and some of you are from the business community and so on. The question then becomes, is it possible that some of the science that should be put in the pipeline ought to use vehicles other than simply NASA's budget as a way of assuring that some of these very valuable scientific missions get flown? Is there some merit in suggesting that the business community buy into some scientific missions and fly those aboard privately held vehicles?

In other words, we take some science right directly into the private enterprise realm.

Dr. **Donahue**. Well, I hate to cop out on a question like this, and legitimately I can plead that my competence is in science and setting science priorities and not in suggesting the proper way or the most effective ways to get our missions into space.

However, I am aware that there are some private companies that have advanced some very interesting ideas for using vehicles that are not in the standard NASA stable of vehicles and that show a great deal of promise for, say, things like the Explorer missions.

Mr. **Walker**. Well, of those 30 or 40 missions that are around, some of which would constitute new starts, are there any of those that we might be looking at that could be moved outside the funding stream of NASA and moved into some other funding stream that would all be a private funding stream?

Dr. **Donahue**. I wouldn't think so, not for basic science. I think that would involve a totally different way of doing business than we have done in the past.

Mr. **Walker**. I understand that. What is wrong, though, with doing things a totally new way if we get them done?

Dr. **Donahue**. Not if we get them done.

Dr. **Lanzerotti**. Mr. Walker, I am a little confused. I could get Tom off the hook, but get myself into trouble. I am a little confused about your question. The ELV's are a separate issue from funding a science or building a satellite. It still take funds to build a satellite.

Then you have to worry about how to launch it. So they are really two separate questions, and the new start request, that request requires a certain amount of OSSA budget, and that is a funding curve or wedge that Tom is alluding to concerning a peak in the funding.

Mr. **Walker**. But I also understood him to say that there might be a problem in terms of just capacity to be able to do those missions at some point?

Dr. **Donahue**. No, I don't think I meant to say that.

Mr. **Walker**. Maybe I misunderstood. In other words, you think that there is going to be plenty of launch capacity at the point that all of these things come onstream in order to get them into orbit?

Dr. **Donahue**. I am assuming that the space transportation system gets over its problems, the tiles and so forth.

Mr. **Walker**. How many missions a year would have to be devoted to science to get us there?

Dr. **Donahue**. To the big missions, only a couple, one or two missions, something on the order of two per year for launching these major missions.

The shuttle manifest offers ample opportunity to do all of the small experiments of the sort that I and Dr. Davidsen talked about. We can do them on the shuttle.

Mr. **Walker**. I am running out of time here, but the problem that I have is if we get the space station flying up there, the shuttle vehicle is going to be absolutely essential for all activities related to the space station, and it seems to me that is a given. It is going to be the only transportation system we are going to have available at that point to do everything that is on station.

If, for example, one-tenth of all your missions have to be devoted in any given year to flying science missions, then that could, in fact, impact on the ability to utilize the station to its full capacity.

What I am suggesting is that here in the mid-1980's, we might want to look at the fact that we will run into problems in the mid-1990's, and begin to discuss alternative means of financing scientific missions and alternative means of flying scientific missions.

And the question is essentially, what thought has been given on that? Is it possible at some point we could seek to buy onto private ELV's in order to fly these? Are there some inherent problems in doing that. And if that is not a problem, is there also a problem with maybe commingling some private entrepreneur's money with NASA money in order to see to it that some of these things get done that are not presently included in the NASA budget for lack of funding resources? Does that make sense?

Dr. **Davidsen**. May I respond to that?

Mr. **Walker**. Sure.

Dr. **Davidsen**. In terms of commingling on the shuttle, itself, this is precisely what we are doing, and the mission I am involved in. We are launching a shuttle which will be carrying a PAM into orbit, for example, and then having done that, having delivered that satellite into orbit which is a commercial enterprise, the shuttle will stay up there for a week and do science, astronomy in this case, with the Astro observatory, which is the thing that is going to look at Comet Halley next spring and then come down. So in some sense, science has gotten a little bit of a free ride on the coat tails of the commercial world in that situation. I think there is not a problem.

Mr. **Walker**. Would you agree that that certainly is going to have to be a pattern which characterizes most shuttles in the mid 1990's?

Dr. **Davidsen**. I think it is an excellent way to enhance science and get science done. It works very well for us. So it is not a problem of getting the missions launched, in my view at least. The problem is that while I am building a telescope and I have some funds and students are being supported well, there are a lot of people with good ideas, perhaps some of them even better than the ones that I have, that are not getting any support from anywhere to actually build their experiments, and the only place they have to turn is NASA where the commercial world is not interested in basic scientific research of the type we do, and it is something that has no immediate commercial significance, no immediate value in terms of the profit motive. It is a long-term investment that we make in the future of our Nation.

Mr. **Walker**. Well, I understand that. Isn't it possible, though, that there are some commercial ventures that are now looking toward the long term in space that might be interested in doing some of those kinds of missions? I wonder how much effort has been put into looking at that. There are some businesses that now understand that there is a long-term future in space that we don't have a good understanding of and may want to be moving in that direction. Has, in fact, that kind of approach been made at all?

Dr. **Davidsen**. I think to some degree yes, and there are certain areas, materials processing comes to mind, where companies are interested in potential activities, obviously. In astronomy, which is a discipline I am familiar with, of course, it is very difficult to see how you are going to turn that into a profit other than by building telescopes or what not at the expense of NASA. So the commercial world is not interested in that sort of thing.

Mr. **Walker**. Diet Pepsi is buying all kinds of things right now. Maybe we can name a star "Diet Pepsi" and get it there.

Dr. **Lanzerotti**. I might point out, the Department of Defense has been very active in some areas of space science. Very active, I should say, to modify that a little bit. The activity goes up and down, and there is not a lot of university support at times, but particularly in the solar physics and space plasma physics area, the Department of Defense participates in that activity.

I think with regard to microgravity and material processing, you will hear more from Dr. Mager and some of his colleagues later.

Dr. **Donahue**. I imagine that Jack Townsend wishes he were up here rather than us to answer these questions.

Mr. **Nelson**. Mr. Andrews.

Mr. **Andrews**. Let me ask all three of you gentlemen just the kind of follow-up on some of the questions Mr. Walker posed to you, just to look at it from a little bit different angle. There are those that have come before this committee from the space science community that have suggested that the shuttle development program has detracted from their efforts and is not necessarily compatible.

I wonder if you care to agree or disagree, maybe comment in general, about that proposition?

Dr. **Donahue**. Well, I feel almost sure that I am one of those who has made comments of that sort to you. As I see it, there were two major problems with the shuttle. One was that there was a long delay in getting it on line and operational, and the decision was made a long time ago to phase out expendable launch vehicles for science missions, and this is fundamentally why we have been waiting so long to get some of our space science missions launched and why there has been a great delay in those major missions that I am talking about.

It was not, as it is often believed, that the shuttle was taking a large part of the budget away from space science. Simple arithmetic will show you that a fraction of the NASA budget devoted to the space sciences remained fairly constant over the years. The trouble has been that the money has not been going to fund new missions, but it has been going to finance an army standing in place. So that is one of the problems that we had with the shuttle.

The other is, as we have alluded to, that we haven't learned how to use the shuttle to do space science. We haven't learned how to carry out or how to use the promised flexibility of the shuttle to do those smaller things that it would seem to be an excellent vehicle to do them with. These are the difficulties we have had with the shuttle.

Dr. **Lanzerotti**. I basically would agree with Tom's assessment. I want to point out, with regard to his closing statement regarding small opportunities, NASA, the science community has not found ways of using it for the small, quick opportunities like the rocket or balloon program.

However, it is important to realize that the shuttle and the space station coming on board should not be used as the sole determinant of the types of science that American scientists will do or will be forced to look at. Near Earth orbital platforms, like the shuttle and the space station, can be ideal for certain science disciplines and can stretch the imagination and can foster one to think about new ways and new science to do.

Astrophysics and Earth observations come immediately to mind as being ideal in those orbits, but it is not possible to carry out some major science objectives of other space science disciplines that we have been doing in the United States, such as planetary science or measurements of the solar wind and the Earth's magnetosphere, possibly getting close to the Sun to understand the solar corona.

And even for astrophysics, for example, it can be used to greater advantage, but there are other research objectives which require maybe smaller free fliers in some instances, like the Spartan. So the potential problem with the shuttle and the space station, which is always lurking in the scientific community's worry, is that they will be forced to think in a mode which does not always foster the best science.

And, finally, because we haven't managed to use it for some smaller opportunities the way we want, it has caused enormous delays, and there is increasingly active programs, but experiments that were selected say in 1978, which was sort of a last call for experiments, still haven't been flown by and large. I don't think any of them have been, and there still looks to be some delay. And that is an impossible situation for creative scientists and for a university community.

Dr. **Davidsen**. The first of those will be the one I was alluding to earlier that I am involved in, which is going to fly next March, so I will have spent 8 years getting ready to fly on the shuttle which is an awfully long time in a university career.

Obviously, we could not have a graduate student involved in a project like that in the very late stages, and we couldn't get tenure. I think the jury is still out on the shuttle. It hasn't done anything for us scientifically yet, but we are still hoping, at least I am.

It has just become operational really in the recent past, and if there is support for the science community to build the experiments that can be done on the shuttle, it may very well turn out to be a very useful tool for us.

Mr. **Andrews**. Thank you, Mr. Chairman.

Mr. **Nelson**. OK, gentlemen, we appreciate your participation. Thank you for sharing your thoughts with us.

Dr. **Lanzerotti**. Thank you.

Dr. **Donahue**. Thank you.

Mr. **Nelson**. I am going to ask the next panel to come up. I want to introduce our second panel on space applications. Testifying will be Dr. Jack Townsend, of Fairchild, who is substituting for Dr. George Harter of TRW, chairman of the National Academy of Engineering Space Applications Board. Dr. Harter could not be here because of our change in the schedule that we had to move this hearing from tomorrow to today.

Next, Dr. Artur Mager, Chairman of NASA Space Applications Advisory Committee, part of the NASA Advisory Panel. Dr. Mager is accompanied by Dean Robert Sekerka of Carnegie Mellon, and Dr. Ronald Greenwood of Fairchild. These two gentlemen do not have formal statements but are here to answer any questions regarding materials processing and remote sensing.

So I want to thank you again for arranging your schedule so that you could meet this revised schedule and apologize for any inconvenience that that might have caused you, and also apologize for the fact that we had to interrupt this hearing to go vote, but such as the way of congressional life. So why don't we start with Dr. Townsend.

STATEMENTS OF DR. JOHN TOWNSEND, MEMBER, SPACE APPLICATIONS BOARD, NATIONAL RESEARCH COUNCIL; AND DR. ARTUR MAGER, CHAIRMAN, SPACE APPLICATIONS ADVISORY COMMITTEE, NASA ADVISORY COUNCIL, ACCOMPANIED BY DEAN ROBERT SEKERKA, CARNEGIE MELLON INSTITUTE; AND DR. RONALD GREENWOOD, FAIRCHILD

Dr. **Townsend**. Fine.

Mr. Chairman, and members of the committee, on behalf of the Space Applications Board of the National Research Council, I would like to thank you for the invitation to participate in this hearing. My purpose is to present the current thinking of the board on NASA space applications program.

Mr. Chairman, I will only highlight parts of the written testimony, and I would ask that it be submitted for the record.

Mr. **Nelson**. Please proceed.

Dr. **Townsend**. Last year we appeared before your subcommittee in support of two major programs. The first of these, the space station, has been approved and is moving forward on a broad front in NASA and its industrial partners. Our report, entitled practical applications of a space station, was published in March of last year and expanded upon the testimony we gave to you.

Also last year we urged reinstatement of the advanced communications technology satellite test program, an undertaking that we had recommended to NASA for several years. We are pleased to note that this is now an approved program and is proceeding well, owing in large part to the initiative of the Congress.

This year the Board's principal concern has been the U.S. program of remote sensing in space, including the roles played by NASA, NOAA, and other Government agencies. The Board and its Committee on Practical Applications Remote Sensing from Space has been studying this situation for a year and a half and are preparing a report that should appear later this year. Nevertheless, it is possible for me to tell you now about the reasons for our concerns.

First of all, in the area of atmospheric observations from space, NASA continues to maintain a strong program in research, the centerpiece of which is the new upper atmosphere research satellite mission. NOAA, however, is responsible for the operation of weather satellites and is having difficulty in maintaining more than one healthy satellite and low polar orbit, and one in geosynchronous orbit. Should either of these satellites fail, our ability to predict weather in the United States and to cooperate in international weather prediction will be seriously impaired. The meteorological community needs two satellites in polar orbit and two in geosynchronous orbit to fulfill the Nation's forecasting expectations. We should not be operating with such a small margin of safety.

As a separate issue from this operational problem, there has developed a serious institutional gap that is of great concern to our Board. In earlier years, NASA designed and operated experimental weather satellites, such as TIROS and NIMBUS that developed new instruments and spacecraft in support of the operational weather satellite system. This activity was planned and implemented by NASA in cooperation with NOAA.

In recent years, this excellent working relationship between NASA and NOAA has all but vanished. The current situation poses a serious threat to the future of our Weather Satellite Program. I would like to say here, it is not in the testimony, that I don't believe this is an instance where we have ill will between the two agencies. They still communicate well. They get along together. I think they have the Nation's best interest at heart. The problem is money.

NASA is no longer actively involved in the planning and implementation of programs that transition new meteorological instruments into operational use. You will ask what should be done to correct this situation and we are endeavoring in our study to find some answers. What we do know is that this institutional gap is serious and needs to be corrected.

The program on ocean observations from space is the last one of the three areas to be addressed and is moving forward slowly. The SEASAT spacecraft returned data for only a few months, but even so it illustrated the great value of satellite observations of the oceans.

Two new projects are coming into fruition. The first of these, the Navy's N-ROSS, is moving forward well. For this project NASA is developing a scatterometer, an instrument that determines wind velocity and direction from sea state measurements. The Board is pleased to note that this development is supported in the present budget request.

The second future mission is called TOPEX, which the previous panel mentioned, that somehow failed to survive the budgetary process this year. We have been assured by Administrator Beggs that TOPEX remains high on NASA's priority list and will probably be recommended as a new start next year.

Our major worry, however, is about Landsat, which in our opinion is in critical condition. The Commerce Department has been moving toward the transfer of this activity to the private sector in accordance with the provisions of Public Law 98-365 enacted by Congress last year. We hope that the transfer will be accomplished, but the current terms of such a transfer leave Landsat in a difficult condition for several reasons.

First a gap in the availability of new Landsat data seems inevitable, and the situation grows more serious with each delay in consummating the transfer.

Second, under present terms, there promises to be little improvement in the quality of Landsat data during the period of private operation. And by quality here, I mean new types of earth remote sensing data. We hope the data will come more quickly than they have in the past, but the quality of the data has been excellent in the past.

Finally, other nations, particularly France, are about to orbit systems that will provide data of superior quality in some respects and will make our competitive position difficult. Our Nation needs to decide if it wishes to maintain a productive, competitive remote sensing capability for civil purposes and act on that decision.

If transfer to the private sector is not accomplished, our capability degrades rapidly as a result of past decisions. There is no plan in the Government for a continuation of the U.S. land-remote sensing program beyond Landsat 5. A gap in the availability of data is not only probable but almost certain.

Why has the situation come to pass, and what can be done about it? Should we not be competitive in remote sensing? These are questions that the Board is studying and plans to address in its report. Nevertheless, I can say a few things about them now.

The NASA R&D Program in land remote sensing, without which there would be no Landsat, has almost been abandoned. NOAA, struggling to maintain an operational system until it is transferred to the private sector, has little capability for improving the system and for developing the market that is so essential to its future success.

Mr. Chairman, in your letter you ask about our thoughts on NASA's microgravity program. I am pleased to report that in our view the program is moving toward several important experiments in the space shuttle. It is moving well. These experiments should indicate whether the field is ready for further expansion. I should also like to add that we have, in each of these committees in the National Research Council, a regular turnover of people, 3-year terms in general, and we will be adding specialists in microgravity in this coming cycle.

Thank you.

[The prepared statement of Dr. Harter follows:]

NATIONAL RESEARCH COUNCIL
COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS
2101 Constitution Avenue Washington, D.C. 20418

SPACE APPLICATIONS BOARD (202) 334-3272

Statement by

George A. Harter
Chairman, Space Applications Board
National Research Council

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
U.S. House of Representatives
February 27, 1985

Mr. Chairman and Members of the Committee:

On behalf of the Space Applications Board of the National Research Council, I would like to thank you for the invitation to participate in this hearing. My purpose is to present the current thinking of the Board on the space applications program.

My name is George Harter; I have been a member of the Space Applications Board since 1981 and have been chairman since December 1982. I am presently employed by TRW Incorporated, Los Angeles, California, as Vice President and Assistant General Manager for the Electronics and Defense Sector. Since joining TRW in 1957, I have held a number of technical and managerial positions in the spacecraft and electronics fields. A biography is attached to this statement.

The Space Applications Board was formed by the National Academy of Engineering in 1973, and is now a part of the National Research Council, the operating organization of the National Academies of Sciences and

The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering to serve government and other organizations

Engineering. The Board's functions are to help formulate the nation's program for practical applications of space systems, to give independent advice to NASA and other agencies, and to assist in broadening the understanding of industry, universities, and the public of the practical applications of space technology.

Last year we appeared before your subcommittee in support of two major programs. The first of these, the space station, has been approved and is moving forward on a broad front in NASA and its industrial partners. Our report, "Practical Applications of a Space Station" was published in March of last year and expanded upon the testimony we gave to you.

Also last year, we urged reinstatement of the Advanced Communications Technology Satellite flight-test program, an undertaking that we had been recommending to NASA for several years. We are pleased to note that this is now an approved program and is proceeding well, owing, in large part, to the initiative of this committee and the congress as a whole.

This year, the Board's principal concern has been the U.S. program of remote sensing in space, including the roles played by NASA, NOAA, and other government agencies. The Board and its Committee on Practical Applications of Remote Sensing from Space have been studying this situation for a year and a half, and are preparing a report that should appear later this year. Nevertheless, it is possible for me to tell you now about the reasons for our concerns.

Remote sensing from space involves observing the earth with instruments carried in satellites: probing the earth's atmosphere, which supports weather prediction and climate studies; viewing the earth's oceans, which has both scientific and practical uses, and observing the earth's land masses, with its applications to mapping, land use, oil and mineral exploration, agriculture, forestry, and the management of other earth's resources. This wide-ranging activity, that has been promoted and developed by the U.S. government for almost 25 years, is now in a state of decline and is approaching a critical condition. Other nations now entering this field, are not only aggressive competitors, but also threaten our leadership position. It is important to understand why this is happening and to consider what should be done to reverse the decline is U.S. activity.

In the area of atmospheric observations from space, NASA continues to maintain a strong program in research, the centerpiece of which is the new Upper Atmosphere Research Satellite mission. NOAA, however, is responsible for the operation of weather satellites and is having difficulty in maintaining more than one healthy satellite in low-polar orbit and one in geosynchronous orbit. Should either of these satellites fail, our ability to predict weather in the United States, and to cooperate in international weather prediction, would be seriously impaired. The meteorological community needs two healthy satellites in polar orbit and two in geosynchronous orbit to fulfill the nation's forecasting expectations. We should not be operating with such a small margin of safety.

As a separate issue from this operational problem, there has developed a serious institutional gap that is of great concern to our Board. In earlier years, NASA designed and operated experimental weather satellites, such as TIROS and NIMBUS, that developed new instruments and spacecraft in support of the operational weather satellite system. This activity was planned and implemented by NASA in cooperation with NOAA. In recent years, this excellent working relationship between NASA and NOAA has all but vanished, the current situation poses a serious threat to the future of our weather satellite program.

NASA is no longer actively involved in the planning and implementation of programs that transition new meteorological instruments into operational use. You will ask what should be done to correct this situation and we are endeavoring in our study to find some answers. What we do know is that this institutional gap is serious and needs to be corrected.

The program on ocean observations from space is the last one of the three areas to be addressed and is moving forward slowly. The SEASAT spacecraft returned data for only a few months. But even so, it illustrated the great value of satellite observation of the oceans. Now, two projects are coming into fruition: the first of these, the Navy's N-ROSS is moving forward well. For this project, NASA is developing a scatterometer, an instrument that determines wind velocity and direction from sea state measurements. Our Board is pleased to note that this development is supported in the present budget request. The second future mission is called TOPEX, the Ocean Topography Experiment, which was to have been a NASA new start this year, but somehow failed to survive the budgetary process. We have been assurred by Administrator Beggs that TOPEX remains high on NASA's priority list and will probably be recommended as a new start next year.

Our major worry however, is about Landsat, which in our opinion is in critical condition . The Commerce Department has been moving toward a transfer of this activity to the private sector in accordance with the provisions of PL 98-365, enacted by congress last year. We hope that the transfer will be accomplished, but the current terms of such a transfer leave Landsat in a difficult condition for several reasons.

First, a gap in the availability of new Landsat data seems inevitable and the situation grows more serious with each delay in consummating the transfer.

Second, under present terms, there promises to be little improvement in the quality of Landsat data during the period of private operation.

Finally, other nations, particularly France, are about to orbit systems that will provide data of superior quality in some respects and will make our competitive position difficult. Our nation needs to decide if it wants to maintain a productive, competetive remote sensing capability for civil purposes and act on that decision.

If transfer to the private sector is not accomplished, our capability degrades rapidly as a result of past decisions. There is no plan in the government for continuation of the U.S. land remote sensing program beyond Landsat 5. A gap in the availability of data is not only probable but almost certain. Why has this situation come to pass and what can be done about it? Should we not be competitive in remote sensing? These are questions that we are studying and plan to address in our report. Nevertheless, I can say a few things about them now. The NASA R&D program in land remote-sensing, without which there would be no Landsat, has been almost abandoned. NOAA, struggling to maintain an operational system until it is transferred to the private sector, has little capability for improving the system and for developing the market that is so essential to future success.

We will be discussing these matters at much greater length in our report, including appropriate federal and private sector roles. I recognize that my testimony tells a tale of degradation of a national technological resource which should be aired for national discussion as we assess priorities in a period of budgetary stringency.

In your letter Mr. Chairman, you also asked about our thoughts on NASA's microgravity program. I am happy to report that this program is moving toward several important experiments in the space shuttle. These experiments should indicate whether the field is ready for further expansion.

Mr. Chairman this concludes my statement.

George A. Harter
Vice President & Assistant General Manager
TRW Electronics & Defense

George A. Harter is vice president and assistant general manager of the Electronics & Defense sector. This sector consists of the company's worldwide business in commercial electronic components equipment and services, and the defense, space and energy systems businesses.

Mr. Harter was previously vice president of the Planning & Investment department, where he held corporate responsibility for strategic planning, acquisitions, mergers, capital expenditures, and major new product, program and plant investments. Included was an international dimension, with a vice president-Europe located in Paris and a vice president-Asia/Pacific located in Tokyo.

Before that, Mr. Harter was vice president and general manager of TRW Aircraft Components Group.

He joined TRW in 1957 and held a number of key technical and managerial positions in the spacecraft and electronic fields. He became a vice president and general manager of Space Vehicles Division in March, 1971. The division designs, develops and manufactures unmanned satellites for the Department of Defense, National Aeronautics and Space Administration, and commercial customers.

He then served as vice president and general manager of the Electronic Systems Division, where more than 3,000 engineering, scientific and manufacturing personnel performed applied research, hardware design and development, fabrication, integration, and test of electronic systems.

He later served as vice president and assistant general manager of TRW Defense and Space Systems Group, an organization employing more than 15,000 people serving military and aerospace markets.

Mr. Harter has been elected to membership into the National Academy of Engineering (NAE) and has been honored as a Distinguished Engineering Alumnus by both Purdue University and Ohio State University. He is chairman of NAE's Space Applications Board, which serves in an advisory capacity to the National Aeronautics and Space Administration's Associate Administrator for Space Applications.

He received a B.S. and an M.S. in Mechanical Engineering from Purdue University and an M.S. in Electrical Engineering from Ohio State University. He completed the UCLA Executive Program in Business Management in 1967. He is an associate fellow of the American Institute of Aeronautics and Astronautics (AIAA) and a member of Tau Beta Pi, Pi Tau Sigma and Sigma Xi.

Mr. Harter and his wife Helen live in Torrance, California. They have two children.

Mr. **Nelson**. Dr. Mager.

Dr. **Mager**. Thank you.

Mr. Chairman, and members of the subcommittee, we deeply appreciate the opportunity to testify before you on behalf of the Space Applications Advisory Committee regarding issues related to the NASA Space Applications Program. I serve as Chairman of the Space Applications Advisory Committee, and appearing with me are Dr. Ronald Greenwood, Chairman of our Remote Sensing Subcommittee, and Dean Robert Sekerka who chairs our Microgravity Science and Applications Subcommittee. Since this is the first time we have appeared before you, let me begin with a few words about our committee.

Mr. Chairman, in the interest of time, I will now skip some of the paragraphs contained in the written record which describe who we are and our committee structure, and instead I will just say that we are a NASA standing committee with responsibility for one, communications; two, microgravity science and applications, meaning the studies of chemical, physical, biological, and materials processing under microgravity conditions in space; and, three, remote sensing of the Earth, its land, oceans, and atmosphere for civilian purposes.

We have subcommittees in each of these areas, and in addition, we have recently established a Subcommittee on Information Systems because we feel that such systems will play an increasingly important role in future space applications.

I would now like to proceed to the discussion of the space applications program. Though we have not taken a formal position on some of the issues I will raise, nevertheless I will try to submit our view.

We were very glad to see that the Advanced Communications Technology Satellite [ACTS] was approved as a flight program. The committee, after its review of the ACTS program, strongly supported the need for a flight demonstration of the system. We note, however, that ACTS is the first communications flight project to reach the approval stage in over 15 years. During that time, there has been a growth in satellite communications capabilities in Europe and Japan that may well threaten the U.S. leadership in this field. So it is important that ACTS move ahead vigorously.

Our Communications Subcommittee is expecting to review the ACTS Experiment Program and help NASA formulate the rationale for the Mobile Communications Satellite Program currently being studied. The latter program should be particularly well suited for provision of mobile communications in nonurban areas of the United States and our hemisphere. Since NASA is planning to carry it out under a cooperative arrangement, its implementation would mark another step toward industrial cost sharing in advanced space R&D. The subcommittee is also expecting to work with NASA on the architecture of the all-important search and rescue space system.

We feel that these three programs, along with the maintenance of a pertinent advanced technology base, are very important to our Nation and should be strongly supported. However, without further study, we are not in a position to comment on the appropriateness of their current or proposed funding, and we intend to address that question in the near future.

Next I will proceed to the discussion of microgravity science and applications. As you undoubtedly know, in the mid-1970's, as a result of the National Research Council's STAMPS study, in which Dean Sekerka participated, NASA reformulated its microgravity program toward more fundamental ground-based research in materials science and processes. Our Microgravity Science and Applications Subcommittee fully supports the current structure and conduct of this program and applauds the direct involvement of industrial firms through joint endeavor agreements and other arrangements.

So it can be said that the ground research program is moving along well. However, up to this time, our flight experience is really quite meager in terms of actual experimental time needed to assure reproducibility of results and to provide a sound data base comparable to that which is employed in conventional materials research. The lack of such flight experience is becoming more and more acute as we prepare to build the space station. Since the station will, for the first time, permit processing, with continued manned interaction in microgravity environment for a long time, it may open many new opportunities for commercial utilization of space. Indeed, the President, in his State of the Union address, mentioned such a possibility in connection with biomedical processing and production of crystals.

But if the space station is to be employed for these purposes, it is necessary to begin now to develop the techniques and facilities to be used on it and build into it. That is why we must acquire a sound data base which incorporates flight experience in actual microgravity environment without any further delay. In this process, the shuttle could be quite useful, but the shuttle microgravity flight program has been limited by both budgetary constraints and manifest priorities. Thus, although we are glad to see some increase in the proposed fiscal year 1986 funding for microgravity research, we feel that it is not enough. A much greater increase, perhaps doubling, is clearly required. Of course, the reordering of shuttle manifest priorities is also needed.

Next I would like to proceed to remote sensing. Over the last two decades, but particularly since 1978, satellite remote sensing of the Earth has found useful and beneficial applications in a wide variety of fields. Many of those applications can be traced to research and development initiated and conducted by NASA. Hence, we feel that the NASA capability, not only in sensor and system development, but also in data processing, data analysis, and applications research, is a national asset. We feel it vital that the Nation continue to utilize that asset to its fullest potential.

From its review of the remote sensing programs and discussions with officials from NASA and NOAA, the Remote Sensing Subcommittee believes that there is a continuous spectrum of required remote sensing research and development activities which ranges from basic Earth sciences to very specialized applications. They also believe that there should be no hard and fast distinction between science and applications.

But the subcommittee is quite concerned about the imbalance in funding which they perceive to exist between the basic sciences and the applications in NASA's remote sensing program, with the applications getting but a minimum of support. Furthermore, the subcommittee has identified gaps in the program which interfere with the desirable flow of technological advances to their ultimate commercial and other utilization and which adequate funding of research into remote sensing applications, as well as some redefinition of institutional responsibilities, would prevent from occurring.

To be more specific, let us consider what has happened in the area of weather satellites. Historically, NASA has funded and developed prototype operational meteorological satellites. Both spacecraft and sensor systems were provided by NASA to NOAA. However, after fiscal year 1984, NASA funding for these activities ceased, and NOAA has been unable to provide funding for an equivalent program.

The net result of this impasse is that needed applications research in the area is not being done, we are still unable to make accurate extended range weather forecasts, and we are still unable to accurately observe the duration and complete distribution of ordinary, as opposed to heavy and violent, rainfall. NASA, while continuing to develop new meteorological sensors which eventually may overcome these and other shortcomings, lacks the opportunity to smoothly transfer their newly developed technology to operations—a gap which seriously interferes with the effectiveness of the weather satellite program and which badly needs closing.

Similarly Seasat, in 1978, was an excellent proof-of-concept system which demonstrated the feasibility and usefulness of ocean remote sensing. But there have been no successor research systems. And though the Navy is moving to demonstrate the technology required for its pressing operational needs with N-ROSS, the next planned experimental system which should significantly advance remote sensing capabilities in that area and provide us with much needed information on ocean topography, and thus its currents, is the Ocean Topography Experiment [TOPEX]. But Topex is still awaiting funding in spite of the fact that it has had high priority on the Office of Space Science and Applications list for some years now. So here, too, is a gap in remote sensing applications research which needs closing.

In the area of land remote sensing, the NASA research program has been properly reoriented toward fundamental research into the physics of remote sensing and the use of remote sensing techniques to conduct earth science. The Remote Sensing Subcommittee views this as a justified swing of the pendulum after several years of very empirical applied research.

However, even though the Landsat system was transferred to NOAA, NOAA has not developed a capability, nor do they have the funding for research into the technology, techniques, and application of land remote sensing. This is particularly important because such R&D is needed to expand the use of acquired data which, from a commercial standpoint, should eventually translate into its greater marketability.

Furthermore, we understand that the funding arrangement for the commercialization of the Landsat system precludes the potential system operator from developing new system capabilities, such as the use of solid-state focal plane arrays, beyond that of the existing thematic mapper, a restriction which, in the absence of other research, must eventually lead to early obsolescence. Hence, it is obvious that there are also gaps which need closing in the research and development of remote sensing for land applications.

It is possible that some of these problems may be due to uncertainties regarding NASA's future role in applications of remote sensing and a division of R&D responsibility between NASA and the operational agencies, such as NOAA. If so, the several planning activities now underway, especially the joint NASA/NOAA planning required by the Land Remote Sensing Commercialization Act and the NASA Long-Range Plan for Space Applications, may provide the means to address and perhaps resolve some of these issues. In any case, we feel that additional funding needs to be allotted to research connected with the applications of remote sensing in order to close the existing gaps which rapidly threaten the U.S. preeminence in this area.

To summarize, we have called your attention to two important issues in NASA's Space Applications Program: One, the microgravity processing activities on shuttle flights need to be expanded without delay, because the data that they will provide may be essential to the possible, and eventual, commercial utilization of the space station; and, two, in remote sensing, the desirable flow of technological advances to their ultimate commercial and other uses is being seriously interrupted by overlapping institutional responsibilities and inadequate funding of research connected with applications.

Mr. Chairman, let me assure you that the Space Applications Advisory Committee fully intends to continue its advisory oversight in all these areas of space applications and to participate in the early reviews of the ongoing planning. In this way, we will be involving our members who, as I mentioned before, represent the users, academia, and industry in the development of needs and meaningful objectives for NASA's R&D effort in the space applications area.

Thank you again for this opportunity to present our views, and we will be glad to answer any of your questions.

[The prepared statement of Dr. Mager follows:]

Hold for release until
presented by Witness
February 27, 1985

Statement of

Dr. Artur Mager
Chairman of the Space Applications Advisory Committee
of the

NASA Advisory Council

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

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Statement of

Dr. Artur Mager
Chairman of the Space Applications Advisory Committee
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Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

We deeply appreciate the opportunity to testify before you on behalf of the Space Applications Advisory Committee regarding issues related to the NASA's space applications program. I serve as Chairman of the Space Applications Advisory Committee, and appearing with me are Dr. Ronald Greenwood, Chairman of our Remote Sensing Subcommittee, and Dean Robert Sekerka who chairs our Microgravity Science and Applications Subcommittee. Since this is the first time we have appeared before you, let me begin with a few words about our Committee.

The Space Applications Advisory Committee is a standing committee of NASA's Advisory Council which, as you know, is NASA's senior advisory body established to counsel the Agency on its policies, programs, and plans. The Council's Chairman, Mr. Fink, testified before this Subcommittee a number of times in the past and most recently Mr. Anders appeared on his behalf during your hearings in August 1984. To carry out it's work, the Council established a number of standing committees which are charged with advising the Council and NASA within their designated areas of responsibility. For our Committee, these areas are: (1) communications; (2) microgravity science and applications (meaning the studies of chemical, physical, biological and materials processing under microgravity conditions in space), and (3) remote sensing of the earth, its land, oceans, and atmosphere for civilian purposes. We have Subcommittees in each of these three areas, and, in addition, we have recently established a Subcommittee on Information Systems because we feel that such systems will play an increasingly important role in future space applications.

As you can see from the membership list attached to this statement, our Committee represents all facets of the community involved in space applications activities; among us are users, academicians, and industry representatives, all providing effective input to NASA from these other, nonagency sources. Indeed, in addition to the functions mandated by the Council, we also advise the Associate Administrator for Space Science and Applications on any problems of his choosing.

I would now like to proceed to the discussion of the space applications program. Though we have not taken a formal position on some of the issues that I will raise, nevertheless, I will try to faithfully present the Space Applications Advisory Committee's views as I perceive them.

Communications

We were very glad to see that the Advanced Communications Technology Satellite (ACTS) was approved as a flight program. The Committee, after it's review of the ACTS program, strongly supported the need for a flight demonstration of the system. We note, however, that ACTS is the first communications flight project to reach the approval stage in over fifteen years. During that time there has been a growth in satellite communications capabilities in Europe and Japan that may well threaten the U.S. leadership in this field. So it is important that ACTS move ahead vigorously.

Our Communications Subcommittee is expecting to review the ACTS Experiment Program and help NASA formulate the rationale for the Mobile Communications Satellite Program currently being studied. This latter program should be particularly well suited for provision of mobile communications in nonurban areas of the U.S. and our hemisphere. Since NASA is planning to carry it out under a cooperative arrangement, it's implementation would mark another step toward industrial cost sharing in advanced space R&D. The Subcommittee is also expecting to work with NASA on the architecture of the all important search and rescue space system.

We feel that these three programs, along with the maintenance of a pertinent advanced technology base, are very important to our Nation and should be strongly supported. However, without further study, we are not in a position to comment on the appropriateness of their current or proposed funding and we intend to address that question in the near future.

Microgravity Science and Applications

As you undoubtedly know, in the mid-1970's, as a result of the National Research Council's STAMPS study (in which Dean Sekerka participated), NASA reformulated it's microgravity program towards more fundamental, ground-based research in materials science and processes. Our Microgravity Science and Applications Subcommittee fully supports the current structure and conduct of this program and applauds the direct involvement of industrial firms through joint endeavor agreements and other arrangements.

So it can be said that the ground research program is moving along well. However, up to this time, our flight experience is really quite meager in terms of actual experimental time needed to assure reproducibility of results and to provide a sound data base comparable to that which is employed in conventional materials research. The lack of such flight experience is becoming more and more acute as we prepare to build the Space Station. Since the Station will, for the first time, permit processing, with continued manned interaction in microgravity environment for a long time, it may open many new opportunities for commercial utilization of space. Indeed the President, in his State of the

Union address, mentioned such a possibility in connection with biomedical processing and production of crystals. But if the Space Station is to be employed for these purposes, it is necessary to begin now to develop the techniques and facilities to be used on it and built into it. That is why we must acquire a sound data base which incorporates flight experience in actual microgravity environment without any further delay. In this process, the Shuttle could be quite useful, but the Shuttle microgravity flight program has been limited by both budgetary constraints and manifest priorities. Thus, although we are glad to see some increase in the proposed FY 1986 funding for microgravity research, we feel that it is not enough. A much greater increase, perhaps doubling, is clearly required. Of course, the reordering of Shuttle manifest priorities is also needed.

Remote Sensing

Over the last two decades, but particularly since 1978, satellite remote sensing of the earth has found useful and beneficial applications in a wide variety of fields. Many of those applications can be traced to research and development initiated and conducted by NASA. Hence, we feel that the NASA capability, not only in sensor and system development, but also in data processing, data analysis, and applications research, is a National asset. We feel it vital that the Nation continue to utilize that asset to it's fullest potential.

From its review of the remote sensing program and discussions with officials from NASA and NOAA, the Remote Sensing Subcommittee believes that there is a continuous spectrum of required remote sensing research and development activities which ranges from basic earth sciences to very specialized applications. They also believe that there should be no hard and fast distinction between science and applications. But the Subcommittee is quite concerned about the imbalance in funding which they perceive to exist between the basic sciences and the applications in NASA's remote sensing program, with the applications getting but a minimum of support. Furthermore, the Subcommittee has identified gaps in the program which interfere with the desirable flow of technological advances to their ultimate commercial and other utilization, and which adequate funding of research into remote sensing applications, as well as, some redefinition of institutional responsibilities would prevent from occurring.

To be more specific, let us consider what has happened in the area of weather satellites. Historically, NASA has funded and developed prototype operational meteorological satellites. Both spacecraft and sensor systems were provided by NASA to NOAA. However, after fiscal year 1984, NASA funding for these activities ceased and NOAA has been unable to provide funding for an equivalent program. The net result of this impasse is that needed applications research in this area is not being done, we are still unable to make accurate extended range weather forecasts, and we are still unable to accurately observe the duration and complete distribution of ordinary (as opposed to heavy and violent) rainfall. NASA, while continuing to develop new meteorological sensors which eventually may overcome these and other shortcomings, lacks the opportunity to smoothly transfer their newly developed technology to operations--a gap which seriously interferes with the effectiveness of the weather satellite program and which badly needs closing.

Similarly Seasat, in 1978, was an excellent proof-of-concept system which demonstrated the feasibility and usefulness of ocean remote sensing. But, there have been no successor research systems. And though the Navy is moving to demonstrate the technology required for its pressing operational needs with NROSS, the next planned experimental system which should significantly advance remote sensing capabilities in that area and provide us with much needed information on ocean topography (and thus it's currents) is the Ocean Topography Experiment (TOPEX). But TOPEX is still awaiting funding in spite of the fact that it has had high priority on the Office of Space Science and Applications list for some years now. So here, too, is a gap in remote sensing applications research which needs closing.

In the area of land remote sensing, the NASA research program has been properly reoriented toward fundamental research into the physics of remote sensing and the use of remote sensing techniques to conduct earth science. The Remote Sensing Subcommittee views this as a justified "swing of the pendulum" after several years of very empirical applied research. However, even though the Landsat system was transferred to NOAA, NOAA has not developed a capability, nor do they have the funding for research into the technology, techniques, and application of land remote sensing. This is particularly important because such R&D is needed to expand the use of acquired data which, from a commercial standpoint, should eventually translate into it's greater marketability. Furthermore, we understand that the funding arrangement for the commercialization of the Landsat system precludes the potential system operator from developing new system capabilities (such as the use of solid-state focal plane arrays) beyond that of the existing thematic mapper, a restriction which, in absence of other research, must eventually lead to early obsolescence. Hence, it is obvious that there are also gaps which need closing in the research and development of remote sensing for land applications.

It is possible that some of these problems may be due to uncertainties regarding NASA's future role in applications of remote sensing and a division of R&D responsibility between NASA and the operational agencies such as NOAA. If so, the several planning activities now underway, especially the joint NASA/NOAA planning required by the Land Remote Sensing Commercialization Act and the NASA Long-Range Plan for Space Applications, may provide the means to address and perhaps resolve some of these issues. In any case we feel that additional funding needs to be allotted to research connected with the applications of remote sensing in order to close the existing gaps which rapidly threaten the U.S. preeminence in this area.

To summarize, we have called your attention to two important issues in NASA's space applications program:

1. The microgravity processing activities on Shuttle flights need to be expanded without delay, because the data that they will provide may be essential to the possible, and eventual, commercial utilization of the Space Station, and

2. In remote sensing, the desirable flow of technological advances to their ultimate commercial and other uses is being seriously interrupted by overlapping institutional responsibilities and inadequate funding of research connected with applications.

Mr. Chairman, let me assure you that the Space Applications Advisory Committee fully intends to continue it's advisory oversight in all these areas of space applications and to participate in the early reviews of the ongoing planning. In this way, we will be involving our members who, as I mentioned before, represent the users, academia, and industry in the development of needs and meaningful objectives for NASA's R&D effort in the space applications area.

Thank you, again for this opportunity to present our views and we will be glad to answer any of your questions.

Mr. ANDREWS [presiding]. Thank you, Doctor.

Let me address a few questions to Dr. Townsend and Mr. Greenwood, if I might. What is the situation right now with respect to the commercialization of remote sensing? In your opinion, is there a chance that we will not have an operational remote land sensing system?

Dr. TOWNSEND. Yes, I will answer that question. I think there is a very good chance we will not make the transfer. It is fairly common knowledge that the decision appears imminent now, a matter of weeks, and I think it could be amost likely that the transfer is not effected.

Mr. ANDREWS. Do you think that we should have an operational civilian land remote sensing system?

Dr. TOWNSEND. Yes.

Mr. ANDREWS. I assume that you do, and the next question is why?

Dr. TOWNSEND. Why? In my view, land remote sensing has a very, very bright future. It is a way of covering large areas for scientific and applications purposes that can't possibly be covered in any other way, by foot or by car or by airplane.

Also, in many of the areas of land remote sensing, the scientific areas and applications areas of interest are worldwide in nature. The satellite provides the ideal vehicle to make global observations, probably the only way you can do that. The same could be said for the sea and the atmosphere.

The problem, I think, is simply that we are not far enough along in the art, if you will, of commercialization of land remote sensing products. The market is very uncertain. But, there is a market. It is a Government market and at the present time, it is relatively small. I do firmly believe that there will be eventually a large market, but I don't think it is going to happen in the next few years, and I think it is just a matter of timing.

My personal concern is that perhaps we endeavor to do this a little too soon, if there had been a little more applications research, that is, research on how to apply the products before the hand-off had been made or was attempted to be made, then I think we would perhaps have a different outlook.

Mr. ANDREWS. Dr. Greenwood, would you like to add something?

Dr. GREENWOOD. I would like to make one point. I think the one case where we have successfully transferred a system is the operational weather satellite system. I think it should be remembered that it has taken us over 20 years to do that. It took 20 operational satellites, seven research satellites, a continuing R&D program, an agency dedicated to applying and making the data work, and a very strong in-house activity within NASA to make that transition successful.

And I think Dr. Townsend is exactly right. We are somewhere in the middle of that process, but we certainly had not put into place that same set of institutions and capability that would be required to make that successful.

Mrs. MEYERS. No questions.

Mr. ANDREWS. Mr. Slaughter.

Mr. SLAUGHTER. No questions.

Mr. ANDREWS. Mr. Chairman.

Mr. NELSON [presiding]. I appreciate it. I apologize that I had to slip out to fulfill a commitment that had been made. I had no idea we would be going past 4 o'clock.

Let's talk about Landsat, and I know you are to go too, Mr. Andrews, thank you very much.

You know we had this rush to want to commercialize, and I am worried about are we doing the right things? Certainly we commercialize here and commercialize there. Suddenly there was an effort we were going to commercialize all the weather satellites, and everybody sort of scratched their heads and said, "Wait a minute." So there emerged a quick consensus last year, and the weather satellites are not going to be commercial.

On Landsat, I wonder, now I know, for instance, earlier today, I can't remember if it was in the morning session or it may have been an earlier panel this afternoon, I asked the question to the panel, we have the negotiation going on with a private enterprise as to what should be a Federal subsidy for this future derivative of Landsat, but that it would not include everything that is on Landsat, and what was being the multispectral scanner was being omitted.

And this particular witness answered that question that that would be devastating in his particular point of view. He thought that we needed the multispectral scanner. The thematic mapper would be included. You all share with us your thoughts then?

Dr. MAGER. Well, Mr. Chairman, I did indicate that the commercial operator, the arrangement would be such that the commercial operator will not be able to proceed with further research and development and not include the thematic mapper, omitting the multilinear array and so on; then our system is very likely to become obsolete in a very short period of time.

Dr. TOWNSEND. Yes.

Dr. MAGER. In fact, the spot system that the French are proposing to build is going to include such an instrument, a different version, but it is going to include such an instrument. I am not proposing that we build the same kind of thing, but nevertheless, here is clearly a state of the art, we are presumably pushing the state of the art, and we have to go that far.

So it seems and if there is not going to be research in that area at NASA, under the proposed commercialization arrangement, Landsat would very rapidly become obsolete. That is my view. I don't know whether Dr. Greenwood would like to comment.

Mr. NELSON. Let me make sure I understand. You are saying that by us not having the capability on a derivative of Landsat for a multispectral scanner, you are saying that that would be a severe handicap for us?

Dr. MAGER. Well, not quite. I said something different.

Mr. NELSON. Let me understand.

Dr. MAGER. It is my understanding, and I might be wrong in that, because I don't know what the final arrangements for commercialization of Landsat are going to be, but it is my understanding that arrangements for commercialization of Landsat will preclude future commercial operator of Landsat from going beyond the thematic mapper.

And what I am saying, in fact, is that nobody else is going to be doing research on things like the multilinear array, for example. The commercial remote sensing system which we will put up will become obsolete in no time, and our foreign competitors are already planning on putting technology which will overpass the technology that our commercial operator will be doing. That is what I am saying.

Mr. **Nelson**. You are saying that the present negotiations are limiting, what you understand it to be, limiting the development of that technology for the future?

Dr. **Mager**. Right.

Dr. **Townsend**. Mr. Chairman, I would like to say something at this point, because Ron and I are both employees of Fairchild Industries, and we competed as a teammate with Kodak for this job, so we have a little bit of past interest in this, perhaps an axe to grind.

Second, I am representing the Space Applications Board, so I will try to be very careful to represent their point of view. If I have a different point of view and you want it, I will give you my own personal point of view. I wanted to make it clear because I know some of my friends in RCA are here in the audience.

We are not trying to bad-mouth the EOSAT proposition. As a matter of fact, the SAB is on record as feeling rather strongly that the attempt should be made to commercialize. What went wrong, in my view, was that the amount of support, and I use the word "support," that the Government proposed has suddenly gone down to a level that in many of our views is inadequate. The market isn't there with support at that level. So that is the problem, not that we think that we shouldn't go ahead with this thing.

Mr. **Nelson**. And what is your personal opinion?

Dr. **Townsend**. Well, in the first place, I guess we do have a little problem. Was it the MLA that—the multispectral linear array?

Mr. **Nelson**. Staff is telling me that apparently the question that I asked to the witness this morning, there was a misunderstanding by the witness of what the question was, and so what I thought he responded apparently was not. He didn't intend to respond to my question the way he did, and it is my understanding now that he is correcting that for the record by sending a response in writing. I didn't know that.

Dr. **Townsend**. Let me say the MLA was an advanced instrument that NASA had under development that they have stopped. That occurred I believe in this year's budget. That instrument is of the sort that Art was talking about that one would wish to fly in future Landsats for new capability, for a new quality of data. The fact that that instrument and others for the future have dropped out of the program concerns all of us, so that is very clear.

I believe the EOSAT does have a base line instrument, which is the multispectral scanner, and is the usual instrument that has been flown all these years. It is possible the witness was concerned because he heard that it wasn't there, and he wanted continuity of data. A lot of people have been buying data for many, many years, and they wanted that same type of data present throughout a longer period of time.

Mr. **Nelson**. OK. Does anybody else on the committee have any questions?

We are going to ask two more questions. Mr. Sekerka, you have been very kind, and I want to address these questions to you.

NASA now calls the MPS Program microgravity science as part of its efforts to disguise application programs. Will this name be reflected in a different way for more near-term practical activities aimed at generating commercial opportunities in space?

Mr. **Sekerka**. Well, let me first respond, Mr. Nelson. The name of the program that used to be material processing in space is now called microgravity science and applications. I think that it is very important to recognize that relative to remote sensing and communications and some of the other applications areas that here we must be careful to integrate science if we are to achieve the sorts of applications that would lead to commercialization.

You heard earlier this afternoon on the science of space, the solar wind and the planets and the stars and what have you. I am talking really here about science conducted in space, not of space, and it is the sort of science that is integral to our understanding of the behavior of materials in a microgravity environment that will, we hope, lead to opportunities and commercialization.

So I think the name is an honest one, and I think that, if anything, applications would be easier to market than science, and so certainly I would not suspect any motivations of the sort that were perhaps inferred.

Mr. **Nelson**. What is your opinion? Is the space station going to be coming along too late in order to significantly affect the MPS?

Mr. **Sekerka**. No, I don't believe so. I think that the fact that the space station is on the horizon 5 to 7 years down the road is a real window of opportunity for this particular program. It is the first opportunity for true proof of concept. We really haven't had very much time in microgravity. I know it seems like a long time that that shuttle was up there, but when you think of how long you are actually conducting microgravity experiments, it is very, very short, and it is really very important that we view this window of opportunity in a way that we rise to meet the opportunity.

It really doesn't make sense, in my opinion, to be spending $8 billion plus on a space station when you have a program here that is $27 million, very much in its infancy, 2 percent of the OSSA budget, that is perhaps one of the most important opportunities for commercialization aboard that station. I think we really do have to rise to the occasion.

We have had a budgetary increase this year where other programs have been cut. I think we are very grateful for that. I wish my budget back at the university had a similar increase. I would be very happy with about 25 percent for this program, but this is a very small, very new program relative to other applications, and I think that we have an opportunity here, and it would be incumbent on all of us to see that we meet that.

Mr. **Mager**. May I say something? I did stress that perhaps doubling was an increase in this particular connection because of the reasons that were mentioned. But the doubling for such a small amount of money is really a very, very small amount. We are talking, I think the present budget calls for $34 million, an increase from $27 million to $34 million, and the doubling of $27 million is relatively not a very large amount of money.

But even if one couldn't get that, one certainly has to be sure that the flight program at this particular time, especially when we are going to build a space station, would be fully utilizing the shuttle for additional data in this area.

Mr. **SEKERKA**. Mr. Nelson, if I might just comment further on that point. Several people today have mentioned the shuttle manifesting priorities, and I have a list here of experiments, some of them have been delayed a couple of years.

Now, of course, the principal investigators who propose those experiments have had to be kept part of the program and had to be kept up to date. You asked someone earlier, where would you make cuts if you had to? I think those are very difficult questions, but certainly we would like to fly these experiments, see what happened and then go on to do new things and not just keep them in the pipeline.

That is an expensive pipeline. Not only don't we get the information, but we keep something alive that we should have thrown a couple of years ago.

Mr. **NELSON**. Well, thank you for this information. I appreciate it very much. You have a list there of a number of projects?

Mr. **SEKERKA**. I have a part of a presentation Mr. Halpern of NASA gave to the Senate staff on January 23. If you would like an additional copy, I am sure I could obtain it.

[This material appears in Appendix 5.]

Mr. **NELSON**. We will submit it, and it will be part of the record. And we will reconvene Thursday, February 28, at 9:30 when we have hearings on the NASA Office of Aeronautics and Space Technology, as well as the Office of Space Commercialization.

Mr. **MAGER**. Thank you very much.

[Whereupon, at 4:45 p.m., the subcommittee was adjourned to reconvene at 9:30 a.m., Thursday, February 28, 1985.]

1986 NASA AUTHORIZATION

THURSDAY, FEBRUARY 28, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:50 a.m., in room 2318, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. **Nelson**. Good morning. The committee will come to order. Today we're continuing our 1986 authorization hearings by focusing on NASA's budget requests for advanced space technology development programs and initiatives designed to foster space commercialization. We're going to hear from two witnesses.

The first witness will be Dr. John Martin, Associate Administrator for NASA's Office of Aeronautics and Space Technology. He'll be followed by Mr. Ike Gillam, Assistant Administrator for NASA's newly created Office of Commercial Space Programs.

This subcommittee has long supported both of these general areas of space activity and therefore, we're looking forward to this opportunity to scrutinize the 1986 budget plans in these areas.

The subcommittee is especially pleased with the increased emphasis that NASA is placing on space commercialization through the creation of the Office of Commercial Programs. And additionally we would like to offer our congratulations to Ike Gillam for being chosen to be the first assistant administrator in that field.

I'd like to thank both of the NASA's witnesses for being here today and before we proceed with the testimony I'd like to recognize the ranking Republican member of the full committee, Mr. Lujan, who has a statement.

Mr. **Lujan**. Thank you, Mr. Chairman, and in the interest of time I ask unanimous consent to include the statement in the record at this point.

Mr. **Nelson**. Without objection.

[The prepared opening statement of Mr. Lujan follows:]

Opening Statement of Hon. Manuel Lujan, Jr.

Thank you, Mr. Chairman.

Today's testimony will give us a better idea of where NASA is going in the development of commercial space programs. There can be no question that space commercialization, and NASA's role in promoting commercial space activities is of vital importance to our Nation. In the years ahead, commercial space activities will make a valuable contribution to our economic base, accounting for thousands of jobs across our country and millions of dollars in the GNP. What those specific figures are is still a matter of debate. One thing is certain: The economic contribution of commercial space activities will increase rapidly in the years ahead, as we begin to take specific steps to encourage commercial space development.

As a Nation, we have a responsibility to encourage space commercialization—not by making it a government-funded operation, but rather by forcing the government to create a set of policies and conditions which foster rather than inhibit entrepreneurial activity in space and space development.

The key—and one without which the door to space commercialization will not open—is cheap, reliable space transportation. The fact is that if the private sector can't get there, it certainly can't make a profit in space. We must guarantee reasonable shuttle prices to the emerging technologies which can only be flown on the shuttle. Payloads and projects which can only be flown on the shuttle should be given the highest priority and our payload policies and pricing policies must reflect these priorities. This is the most important issue our committee will look at this year—as such it should be our highest priority.

During the course of this hearing, we must carefully examine the role NASA has chosen for itself in promoting commercial space activities. Once the issue of shuttle pricing policy is properly resolved, commercial space activities can and will contribute to a thriving, international space economy in the 21st century. This is an exciting program and these are exciting times. I look forward to watching this new frontier open up.

Mr. NELSON. And to recognize my colleague, Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman. I want to join with you in welcoming our witnesses before the committee. As the chairman is well aware, I'm a strong believer in the commercial future of space. Like the conquistadores of nearly 500 years ago, we stand on the threshold of a new universe which is ours to explore and to exploit.

We are now able, for the first time, to view space travel as routine. We cannot forget the space travel is inherently a very risky business. On the other hand, in a few days the shuttle will thunder off the pad on the first out of the world congressional oversight trip.

I must admit that I'm concerned that some of our efforts are not being focused as well as they should be. Throughout our hearings, we've been hearing from witness after witness that the cornerstone of our commercial future in space is materials processing. I believe that members of the committee agree with that analysis. However, we don't seem to see a budgetary commitment to support that kind of technology.

Mr. Chairman, I continue to believe that NASA is the best managed agency in the Government and they do an excellent job of research and development of new technology. Our job is to make sure that they have the adequate resources and that NASA efforts are focused in the right direction. Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Walker.

[The prepared opening statement of Mr. Walker follows:]

OPENING STATEMENT OF HON. ROBERT WALKER

Good Morning, Mr, Chairman. I want to join you in welcoming our witnesses before the committee.

As the Chairman is well aware, I am a strong believer in the commercial future of space. Like the conquistadores nearly 500 years ago we stand at the threshold of a new universe which is ours to explore and exploit.

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Mr. Chairman, I continue to believe that NASA is the best managed agency in the government and that they do an excellent job of research and the development of new technology. Our job is to make sure they have adequate resources and that NASA's efforts are focused in the right direction.

Mr. NELSON. Dr. Martin, you may proceed.

STATEMENT OF DR. JOHN MARTIN, ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY DR. COLLADAY, DEPUTY ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY

Dr. MARTIN. Thank you, Mr. Chairman, members of the subcommittee. I'm pleased to be here this morning to be able to tell you about the NASA Space Research and Technology Program and our proposed budget for fiscal year 1986.

I have with me my deputy, Dr. Colladay, and my directors, who will assist in answering detailed questions that you might have when I finish this brief overview.

With your permission, Mr. Chairman, I'd like to submit my formal statement for the record and treat it in general terms in remarks that I've prepared.

Mr. NELSON. Without objection.

Dr. MARTIN. Thank you.

Last year, in fact starting about January last year, was my first year as the Associate Administrator for Aeronautics and Space Technology and based on that exposure and on my experience in industry, I can say that we are making substantial contributions to the well-being of the Nation's need for critical space technology needs.

Of particular note of our contributions during the past years are the contributions to the space shuttle main engine where our efforts have increased service life and performance levels, to the space station, where we offer technology options that cause—permitted performance levels and reduced life-cycle costs and also to our research in space, which is going forward primarily during the past year on the solar array experiment, but with others that I'll talk about, also, as time goes on here this morning.

But, what I wanted to treat, before I got into the highlights of the fiscal year 1986 program, is our organization of OAST, which was reorganized in August last year. The first slide (fig. 2) shows that organization and the second tier, the middle row of boxes, are called directors for. You see one for institutions, one for space, one for aeronautics. They have primary responsibility for long-range program direction and for near-term emphasis, as that's required. The program that we generate is implemented through five disciplinary divisions, which you see at the bottom of the chart. They are, as I said, disciplinary divisions and they implement the program that is established by the front office and by the directors for. The organization is productive and I think it's probably more productive than it might have otherwise have been because we have a synergism now between our aeronautics effort and our space effort.

There are a couple of vacancies that you see on the chart there. One of them is already filled, Dr. Rosen of California will become the propulsion, power and energy director and we expect the selection for the materials and structures vacancy in a very short time.

Our mission in the space R&T effort is to provide a technical base, a technology base, both of high-payoff technologies and of research that lead to new opportunities that must be based on some rational thinking. It takes many, many years, 20 years or more, to apply a new technology. As a result of that we require a long-range mission model to help us identify high benefit and frequently, high-risk technologies.

Shown in the next slide (fig. 1) is a partial mission model, which refers to along one axis, the decades going through the 2010's and in the other axis, classes of vehicles that we take under consideration, you see there are transportation, spacecraft, and large space systems, large structural systems. It is these driver missions that we have identified that give us some basis for the technology options that we look upon as being fruitful for pursuit.

In transportation, we've been working on a successor to the space shuttle main engine, looking for a longer life, higher thrust engine. We've been working on a reuseable orbit transfer vehicle, where aeromaneuvering in the atmosphere and propulsion technologies will offer good possibilities.

With respect to spacecraft, we have coordinated with the Office of Space Science and Applications and have identified a few potential missions which will guide our technology opportunities, like Mariner Mark II class of spacecraft, a Mars sample return voyage and advanced Earth-observing systems.

In the large space technology area we're proud of what we have brought forth in technology that has laid the basis for the space station and other structures. Large structures that are on the horizon are a large, deployable reflector for the astrophysics program, a large antenna for communications, and in the long term even the potential for a lunar base.

The overarching effort of all of this, however, is in-space experiments, which will permit us to get data that essentially cannot be obtained on Earth, and I'll talk more about that later on in my remarks this morning. The need for the program in space has been clearly recognized for the past few years and we are getting into it with a good deal of effort. In the short term we'll use the shuttle, in the long term we will use the space station for those experiments and for those in-space efforts to prove the economical and technical utility of the options that we bring forth.

I'd like to now summarize very briefly the space R&T budget request which I bring before you. In this chart (fig. 3) the fiscal year 1986 budget request is shown in comparison with fiscal year 1984 and fiscal year 1985 budgets. The request is for $160 million and an additional $8 million is indicated for the standards and practices effort, which is manufactured—which is managed, rather, by the Chief Engineer's office. The major portion of our budget goes for disciplinary efforts, as you see. $20 million goes for technology programs, which are pointed, primarily, towards advanced chemical propulsion systems and in-space

The next chart (fig. 4) shows the distribution of our efforts by the various technical areas. The growth areas in the R&T base are in automation technologies and in aerothermodynamics and predictive techniques for aeroassist and aerobreaking, which will have utility for an orbit transfer vehicle and also, aerothermal structures, which has utilization in that same type of vehicle. The growth in systems technology is primarily in the space shuttle test—space shuttle main engine test bed, which we are going to be utilizing a good deal during fiscal year 1986 and new programs in support of the orbit transfer vehicle and in-space experiment of large controlled flexible structures. I'd like to present now, a few highlights from significant areas of research.

The first of these is automation research. In autonomous systems, the slide (fig. 5) you have before you now, a knowledge based system has been used to automatically detect errors and diagnose faults in a Voyager telemetry stream. Work is underway to integrate automated mission planning into this system to demonstrate rudimentary levels of system autonomy, which might be used in the space station subsystems. We've also made some significant progress in high-speed vision processing, which will lay a basis for a real-time vision-based manipulator control and for robot systems.

In automation technology the shuttle remote manipulator is probably the primary example these days. In the future we envision a much more extensive use of teleoperation, which is to say manual operation through communications and robotics, and of an autonomous control of vehicle operations based on applications of knowledge-based systems. The application of these technologies to the space station has been a major topic of study in NASA in recent months and we will have a report to the Congress by April 1, on that subject. My office has been participating in those studies and is searching for technology options, which will be critical to the automated operations in space. Elements of our expanded automation system are shown in this slide.

The next area that I wanted to go to is orbit transfer vehicles. In particular a space-based reusable vehicle (fig. 6). The key technologies are shown in this slide (fig. 7). First of all, to operate in space, one requires the ability to handle cryogenic materials. Frequently, most often, liquid gases. We have an on-going program which includes on-orbit transfer of cryogenic fluids in zero gravity and we are getting good data from that. In addition to the cryogenic fluids, we require aero-braking capabilities in the atmosphere, as a means of maneuver, and also a high-performance engine, which could significantly reduce the amount of propellant which would be required to be carried to orbit. Such a capability would reduce costs and give greater payload capabilities. There is increased funding in the fiscal year 1986 budget to pursue these efforts and to carry out a flight experiment to do the definition work for a flight experiment in the upper atmosphere with such a vehicle. The requirements for this capability of an OTV require a flight test. You can see in the chart (fig. 9) on the left here that neither ground-based facilities, or using the space transportation system as a test bed, reaches the velocities, nor the altitudes as measured by Reynolds number, that we require. Therefore, the only feasible alternative to obtain the necessary flight data is a flight experiment.

For the propulsion system we are studying engine technologies, which will allow a space-based reusable system, which requires a higher performance. You see on the right of this chart (fig. 9) the payoff in terms of dollars saved in fuel by increases in specific impulse, a measure of engine performance. A few percent of increase can save billions of dollars in the mission model, so there is a considerable payoff, and we are pursuing that.

I'd like to go now to flexible structures, and by flexible structures, large flexible structures, I mean structures which measure tens of meters across. We are exploring new concepts for erecting and deploying such structures in space and to predict their dynamic behavior and how to control them. Shown in this slide (fig. 10) are the elements of the program. They include analytical and modeling techniques, that will permit shape prediction and control systems needs, ground experiments, which lay the basis for our in-space experiments, and because it is not possible to simulate accurately on the ground, we are preparing also for experiments in space on such flexible structures.

One example of such a flexible structure is the large solar array that you see in this slide (fig. 12), which was flown during the past year aboard the shuttle. Analysis showed that some of our predictions were as much as 50 percent in error and we did not predict that the array would take on a curvature when it came from the dark side of the Earth to the sun-lit side. We still haven't figured that out and we need to understand better, such phenomena as they occur. The budget for fiscal year 1986 will allow us to build on what we have learned with the solar array and to begin to test our understanding of dynamic response of large controlled structures (fig. 13). We also carried out—are preparing to carry out, rather, a series of experiments on a flexible truss beam, first to verify dynamic behavior, which is like the shake, rattle and roll of the beam, and then to evaluate distributed control with sensors and actuators and finally, to move on to adaptive control. It is only through such experimentation in space that we can verify our analytical methods and our ground-based tests and to give additional meaning to them.

I'd like to finish off now with a kaleidoscope of a few examples of our in-space experiments. Here (fig. 14) you see a chart which talks to the orbiter being used as a test bed for experiments which we've been doing a number of flights, as you see. The most recent of which was the final bullet, which had to do with finding fluctuations in atmosphere density during reentry. That would be very important to us and we need to have such data, especially for the orbit transfer vehicle activities in the atmosphere.

We carried out the solar array flight experiment (fig. 15) as you've heard. We tested for the first time a system of photovoltaic rays on a 100-foot high tower and found new data on performance of these solar cells, in addition to the dynamic response of the flexible array, which I've alluded to.

We've (fig. 16) had in orbit for about a year now, we'll retrieve it in March, a long duration exposure facility in which the United States and eight foreign countries and a large number of experimenters have been looking at the degrading effects on materials by being exposed in orbit. Such experiments are suitable for exposure in space and which are not. We will recover the LDEF in April—rather in March, and look forward to the data that will come from it. We intend to reuse LDEF in the future as well.

As a test of extracting features from planetary images, we have, in 1984, carried out a feature identification and location experiment, the purpose of which was to test an algorism, which would enrich the data being sent back to Earth so that only data which was being sent would have high information content and not just as the image is taken. You can see in this slide (fig. 17) the difference between the upper right, where the 70-millimeter camera is shown and the processed image, which is in the center left. All the main features are there, but the amount of data required to transmit that back was much less.

We are carrying on also a heat pipe experiment. Operations in space (fig. 18), especially commercial operations in space, will lead to very energetic processes and we have to dissipate that heat. It turns out that in most heat dissipating systems we use a fluid, but the usual properties of fluids are not available to us in space because of the absence of gravity, so we've been working on a two-phase heat pipe, which makes use of fluid properties, which are not gravity dependent for heat rejection systems.

Finally (fig. 19), I want to say a few words about atomic oxygen effects, which have plagued us through a glow and the detrimental attack on surface materials in shuttle flights. We have now understood that the cause of the glow and the surface materials attack was atomic oxygen, which was reacting with those materials. We have identified the chemical processes and we believe that we understand how to go forward now with choosing materials that will not suffer such degradation.

These examples that I've been talking about, Mr. Chairman, I think are giving us a good start on expanding our research laboratory in space. We intend to increase our program in 1986 and to work jointly with the mission-oriented offices of NASA and with the DOD to try to be responsive to their technology needs. We'll try to involve energy—industry also in our efforts in that respect.

Mr. Chairman and members, that completes my presentation of the fiscal year 1986 space R&T program of NASA. I believe it's responsive to our goals of maintaining U.S. preeminence in space and I appreciate this opportunity. If you have any questions we'd be pleased to try to respond to them.

[The prepared statement plus answers to additional questions asked of Dr. Martin follow:]

STATEMENT

OF

Dr. John Martin
Associate Administrator for
Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

I am pleased to be here to summarize for you the NASA Space Research and Technology (R&T) Program and proposed FY 1986 Budget request. Last year was my first year as Associate Administrator for the Office of Aeronautics and Space Technology; based on that exposure, I can say we are making a substantial contribution toward meeting the critical space technology needs of the Nation.

The mission of the Space R&T program is to provide the Agency and the Nation with a store of advanced technology that will enable the United States to maintain its preeminence in space. Our research is a balance between high-payoff technologies which support national needs and research leading to opportunities arising from the laboratory before they are even recognized as mission requirements.

Because it can take as much as twenty years to develop and apply a new technology, we start with a long-range mission model from which we identify high-benefit technologies. The mission model is a match between what one forecasts to be technologically feasible, what one expects the user community demand to be, and what one expects to be within budget feasibility. Figure 1 is a partial mission model for transportation, spacecraft, and large space systems. It identifies so-called driver missions for which clear advances in technologies are required to either enhance or enable the mission.

In transportation technology, we have been working on liquid propulsion technology for an advanced cryogenic engine as a future long-life, high-thrust successor to the current Space Shuttle Main Engine (SSME). I will describe later some additional research leading to the technology to support a space-based, reusable orbit transfer vehicle. In the longer term, we forecast the need for a trans-lunar orbit transfer vehicle and advanced earth-to-orbit vehicles.

In spacecraft technology, we have been working closely with the Office of Space Science and Applications to provide the enabling and enhancing technologies for potential missions, such as the Mariner Mark II class of spacecraft, a Mars sample return, instruments for advanced Earth-observing systems, and advanced components for future communications systems.

In large space systems technology, we are proud of our past and continuinig research which has contributed to the capability for the Space Station. But other large structures loom on the horizon; a large deployable reflector for the astrophysics program, a fifty-meter antenna for communications satellites; and, in the long term, the potential of a lunar base.

In characterizing our program, it should be recognized that there is one additional thrust, one which overlays our focus in transportation, spacecraft, and large space systems. This thrust is to develop the capability to perform in-space experiments when essential data cannot be obtained on Earth. The need to extend our ground-based laboratory program into space has become recognized clearly over the last few years, and is the focus for a number of the programs that I will describe to you. In the near term, we will continue to exploit the Shuttle for short-duration experiments. In the longer term, we envision a permanent in-space research and technology capability on the Space Station with technology development missions to verify economic and technological benefits from space operations.

Before I discuss some highlights in our FY 1986 program, I would like to describe the reorganization of the Office of Aeronautics and Space Technology that took place last August, as shown in Figure 2. The responsibilities of the three Directors For are to provide long-range direction and near-term program emphases. The programs are implemented through the five divisions which represent all of the discipline research that we conduct. The Flight Projects Division is evidence of my belief in the importance of establishing a capability for in-space flight research. I believe the organization is productive and has combined in a meaningful way the appropriate aspects of our research in space with those in aeronautics. For instance, our aeronautical propulsion activities are managed in the Propulsion, Power and Energy Division, as is our research on advanced cryogenic and liquid oxygen/hydrocarbon space engines. I expect the reorganization to be completed by mid-March.

The OAST budget request of $160 million for FY 1986 is shown in Figure 3. Also shown is $8 million for Standards and Practices which is managed by the Office of the NASA Chief Engineer. In the Standards and Practices program activities related to Agency productivity, safety, systems engineering, reliability and quality assurance will be continued. The $3.1 million increase reflects a broadened non-destructive evaluation program, and consolidation of Agency efforts to develop a better understanding of the effects of cosmic rays and radiation on the reliability and performance of microelectronics systems in space. Within the space R&T budget, there is an $11.2 million increase in the Systems Technology programs. This increase is for the planned growth in cryogenic propulsion research which will use the SSME Testbed Engine to evaluate new materials and advanced technology components, and new programs for the control of flexible structures and orbital transfer vehicle technologies.

Figure 4 shows the allocation of the FY 1986 budget to the discipline and system elements of the program. Most of the budget falls in the category of technology development in the generic disciplines applicable to future space systems. The Systems Technology programs allow us to focus on vehicle applications and to perform in-space experiments.

In describing the FY 1986 program, I would like to highlight three research efforts of particular importance: automation; space-based, orbit-transfer vehicle technology; and the control of flexible structures.

We have made significant strides in automation research over the past several years. Figure 5 illustrates our progress on a crucial element of an autonomous system, namely the ability to monitor its operation and automatically diagnose anomalies. This capability was demonstrated in 1983 on a sample Voyager telemetry stream, in which ground system and spacecraft errors and malfunctions were successfully detected and diagnosed. Work is currently underway to integrate automated planning with monitoring and fault-diagnosis software to demonstrate rudimentary levels of system autonomy. An expert system scheduler was also demonstrated for the Kuiper Airborne Observatory Astrophysics Program. We are currently performing evaluations to determine how this technology could be used for autonomous control of Space Station subsystems. In the area of robotics research, a high-speed vision processor, called the Programmable Image Feature Extractor, has been designed and is now being built with the capability of up to ten billion operations per second, sufficient to perform real-time image processing functions such as edge detection. This processor is a vital component of an integrated computer vision and robot control system that has the capability of tracking complex objects and autonomously controlling a robot arm to perform manipulation tasks.

During the past year, we have increased our support of automation research with emphasis on applications to Space Station and to science missions. As shown in Figure 6, current automation technology for manned systems is embodied in devices such as the Shuttle remote manipulator system. We envision much more extensive use of teleoperation and robotics and of autonomous control of vehicle operations based on applications of knowledge-based systems. We have been coordinating extensive studies to identify the most critical technologies in automation for space operations.

The results of these studies will be presented in a detailed report to Congress by April 1, 1985. The elements of this expanded automation research program are shown on the figure and include emphasis on artificial intelligence, tactile and visual sensing, subsystem control, high-level robotic languages and the man-machine interface.

The key technologies, shown in Figure 7, required for a reusable, space-based orbit transfer vehicle (OTV) are in-space cryogenic fluid management, a space-based propulsion system, and the use of aerobraking to offset the need for propellant on the return to low-earth orbit. In order to achieve space basing, the ability to measure, store, and transfer cryogenic materials is essential. We have an ongoing program which includes the on-orbit transfer of cryogenic fluids from one container to another in the zero-G environment. The increased funding in FY 1986 is for propulsion component research leading to an augmentation for ground research engines, and for concept definition of an aeroassist flight experiment in the upper atmosphere to validate aeroassist technologies.

Two examples of our ongoing research to understand the flight behavior of an aeroassist OTV are shown in Figure 8. To the left is shown a result from a new computational prediction technique which obtains flowfield solutions in 400 iterations instead of 20,000 by previous methods. The method is more amenable to simulating the non-equilibrium flow expected during an OTV entry into the Earth's upper atmosphere. To the right is shown a tailorable advanced blanket insulation concept for thermal protection of the high-drag aeroassist device. The concept takes advantage of the successful fibrous ceramic insulation used on the Shuttle in a modification compatible to the aeroassist OTV geometry and entry conditions.

Figure 9 indicates the requirements for both an aeroassist flight experiment and advanced cryogenic engine research being addressed in the FY 1986 program. On the left, it can be seen that our test facilities are incapable of simulating the aeroassist OTV entry conditions. The figure also shows that the Shuttle Orbiter is not an adequate simulation of the type of flow conditions that will be encountered during an aeroassist maneuver. Therefore, a possible future flight experiment appears to be the only alternative to obtain essential data. For the propulsion system, we are studying engine technologies which will allow a space-based, reusable system with performance improvements to reduce the quantity of propellants which must be supplied to low-Earth orbit. As shown on the right, as little as a 6 to 7 percent increase in specific impulse results in a saving of about $2.5 billion for the current mission model.

Turning to our large flexible structures research, we are exploring new concepts for erecting and deploying such structures in space and we need to predict their dynamic response and how to control them accurately. Large space structures generally are more flexible than their Earth-bound counterparts and it is not possible to simulate completely their behavior in a ground-based laboratory.

For large antennas and reflectors, the accuracy of the deployed shape requires improved analyses for shape prediction, identification of antenna characteristics in space, and methods for adaptive, distributed control. Shown in Figure 10 are the elements of the program which include research on analytical methods and modeling techniques for linear and nonlinear distortions, the development of ground-based experiments, and their counterpart in-space experiments. Both ground and in-space experiments are included so we can improve our simulation capabilities.

Shown in Figure 11 is a recent ground test of a vertically mounted beam with an active control system to evaluate structural response and control algorithms for minimizing the effects of dynamic distortions. We expect to duplicate some of these tests in space in order to determine the limits on ground-based simulations. The budget in FY 1986 will allow us to build on the solar array flight test experience of last year, and to develop a test capability to understand structural dynamic response and control of large structures. Preliminary analysis of the solar array flight experiment (Figure 12) indicates that the analytical methods were about 50 percent in error for that relatively simple structure. In addition, the array took on a curved configuration when it returned to sunlight from the dark side, and we have not yet been able to simulate this behavior analytically. As shown in Figure 13, we see a series of experiments with a flexible truss beam, first to verify dynamic behavior, then to evaluate distributed control, and then to add adaptive control. It will be only through such experimentation in space that we will be able to validate new analytical methods, to verify how we can use ground-based tests to qualify large space structures, and determine the limitations of ground testing.

I indicated earlier that I felt we had an underlying need to enhance our ability to conduct in-space experiments, frequently and at a reasonably low cost. Let me illustrate with a kaleidoscope some of the experiments that we have conducted to date. Perhaps the most obvious is our use of the Space Shuttle as an experimental facility. Shown in Figure 14 are typical results from our continuing aerothermodynamic experiments on each Orbiter flight. Last year, for the first time, we obtained entry data which allowed us to define the magnitude of the normal fluctuations in the Earth-entry environment. These variations will have to be accounted for in the design of the flight control system for the aeroassist orbit transfer vehicle.

As shown in Figure 15, last year we tested the first in what we believe will be a series of flight experiments on large photovoltaic system arrays. This test provided new data on the performance of the solar cells as well as providing our first data on the dynamic response of these large flexible arrays.

In FY 1984, we put into orbit the Long Duration Exposure Facility (LDEF), shown in Figure 16, containing 57 different experiments involving a large number of investigators from the U.S. and 8 foreign countries. This device allows us to put experiments into the space environment for a long period of time and provides valuable precursor experience for future long-duration experiments on the Space Station. We will recover LDEF in 1985 and have plans for its reuse.

To provide for more efficient information management and data transfer from space sensors, a Feature Identification and Location Experiment (FILE) was successfully flown aboard the Shuttle in October 1984 (Figure 17). This experiment provided verification of algorithms for autonomous detection and classification of Earth features. This concept, when combined with an onboard data processing system will automatically discriminate between clouds and images of interest, producing a significant increase in the amount of useful data transmitted to Earth.

More advanced thermal control systems will be required for the higher power requirements of future space systems. Figure 18 shows our first in-space experimental evaluation of a two-phase heat pipe for high-capacity heat-rejection systems. A temperature sensitive liquid-crystal coating allowed us to verify the heat pipe operation in zero gravity.

As you are aware, early in the Shuttle program, we encountered a phenomenon comprised of glow and a detrimental attack on surface materials. The source of this problem is atomic oxygen and, as shown in Figure 19, we have conducted a series of pallet exposure tests in the Shuttle payload bay. We are beginning to understand degradation mechanisms and to identify replacement materials and coatings which could minimize or eliminate the difficulty. Other experiments flown in the Shuttle payload bay include the Induced Environment Contamination Monitor (STS-2, 3 & 4) which provided valuable data on the particulate and molecular environment of the Shuttle bay. The Thermal Canister Experiment (STS-3) provided verification of heat-pipe technology for the precise thermal control of sensitive instruments.

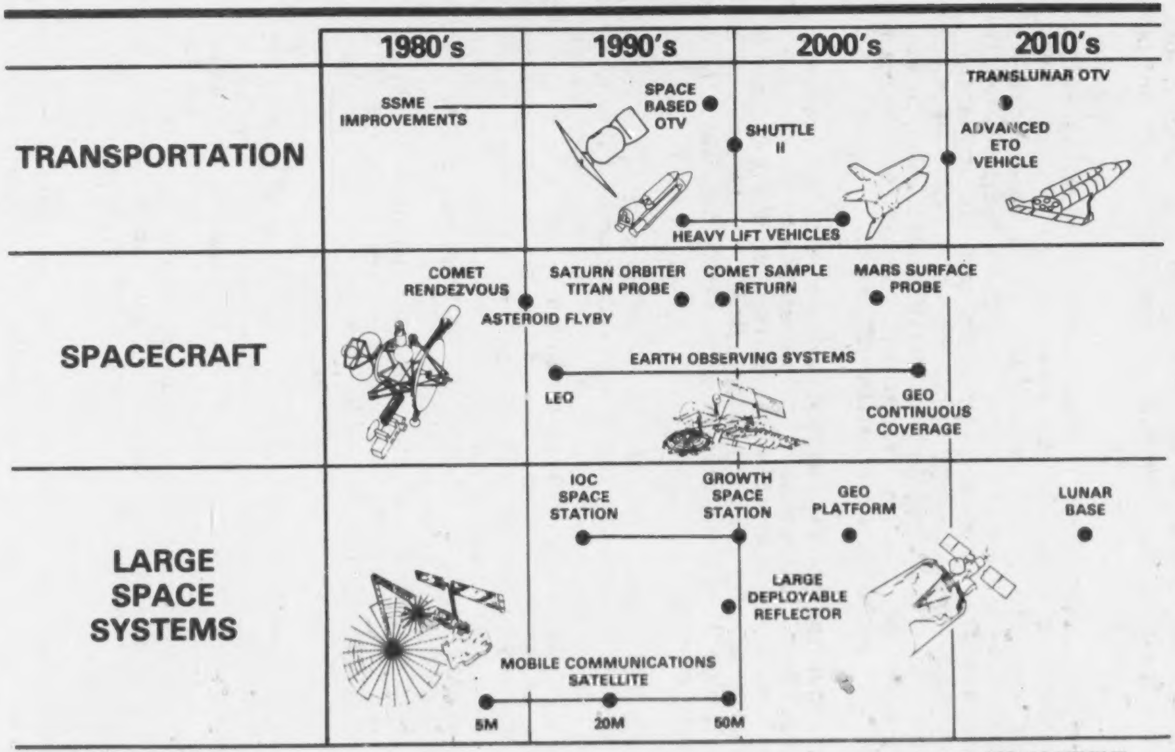
As these examples indicate, we have made a good start toward expanding our research horizons into space. We are increasing our program focus in this area for FY 1986 and are proceeding to plan jointly with the mission-oriented offices in NASA and the DOD to develop further cooperative programs responding to their technology needs. We intend, further, to seek increased involvement by industry to extend their ground-based experimental capabilities into space.

I feel that our proposed FY 1986 program is responsive to maintaining U.S. preeminence in space. It supports Agency goals in space transportation, exploration of the solar system and Earth observation, and development of the Space Station and its extended capabilities. It also supports expanding military and commercial space needs with technology options and research opportunities which will help make future space systems and applications a practical and economic reality.

Thank you for this opportunity to summarize the highlights of our program. I solicit your support.

TECHNOLOGY MISSION MODEL

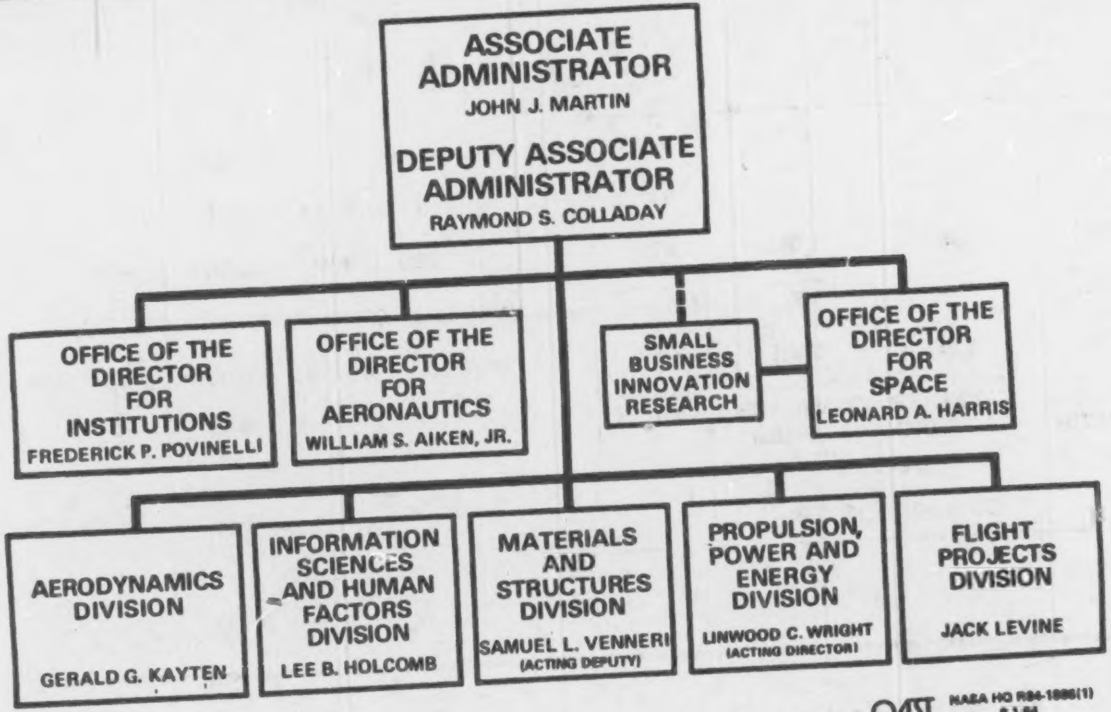
(DRIVER MISSIONS)


1980's
1990's
2000's
2010's
TRANSPORTATION
SSME IMPROVEMENTS
SPACE BASED OTV
SHUTTLE II
HEAVY LIFT VEHICLES
TRANSLUNAR OTV
ADVANCED ETO VEHICLE
SPACECRAFT
COMET RENDEZVOUS
ASTEROID FLYBY
SATURN ORBITER TITAN PROBE
COMET SAMPLE RETURN
MARS SURFACE PROBE
EARTH OBSERVING SYSTEMS
LEO
GEO CONTINUOUS COVERAGE
LARGE SPACE SYSTEMS
IOC SPACE STATION
GROWTH SPACE STATION
GEO PLATFORM
LUNAR BASE
LARGE DEPLOYABLE REFLECTOR
MOBILE COMMUNICATIONS SATELLITE
5M
20M
50M

NASA HQ R85-349 (1)
REV. 1-23-85

Figure 1

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY



ASSOCIATE ADMINISTRATOR
JOHN J. MARTIN

DEPUTY ASSOCIATE ADMINISTRATOR
RAYMOND S. COLLADAY

OFFICE OF THE DIRECTOR FOR INSTITUTIONS
FREDERICK P. POVINELLI

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SMALL BUSINESS INNOVATION RESEARCH

OFFICE OF THE DIRECTOR FOR SPACE
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AERODYNAMICS DIVISION
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INFORMATION SCIENCES AND HUMAN FACTORS DIVISION
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MATERIALS AND STRUCTURES DIVISION
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LINWOOD C. WRIGHT
(ACTING DIRECTOR)

FLIGHT PROJECTS DIVISION
JACK LEVINE

NASA

OAST NASA HQ R84-1886(1)
8-1-84

Figure 2

SPACE RESEARCH AND TECHNOLOGY

	R&D BUDGET ($,M)			
		FY 1985		FY 1986
	FY 1984	BUDGET ESTIMATE	CURRENT ESTIMATE	BUDGET ESTIMATE
RESEARCH & TECHNOLOGY BASE	124.9	136.0	136.3	140.0
SYSTEMS TECHNOLOGY PROGRAMS	7.5	9.1	8.8	20.0
SUBTOTAL SPACE R&T	132.4	145.1	145.1	160.0
STANDARDS & PRACTICES	4.6	4.9	4.9	8.0
TOTAL	137.0	150.0	150.0	168.0

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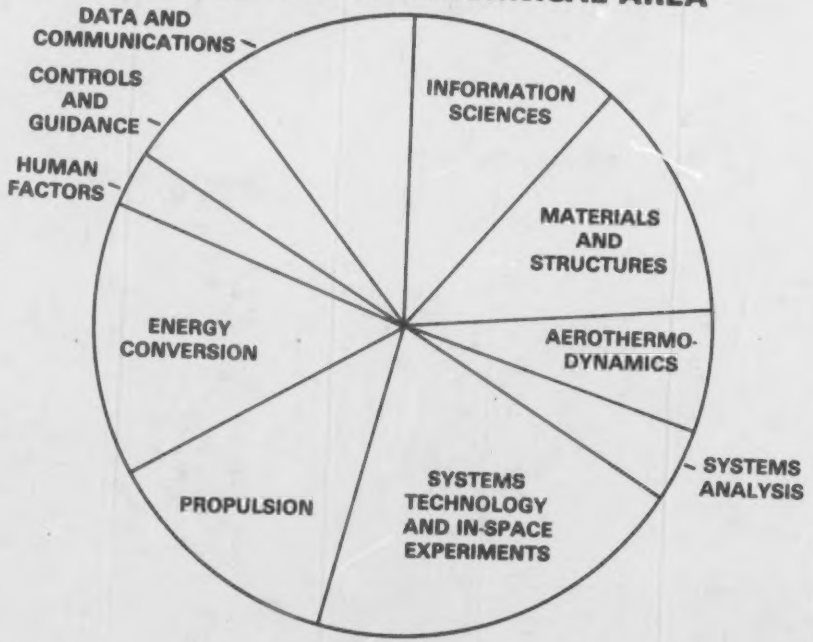
REV. 1-11-85

Figure 3

SPACE RESEARCH AND TECHNOLOGY

DISTRIBUTION BY TECHNICAL AREA



$160 M

NASA

Figure 4

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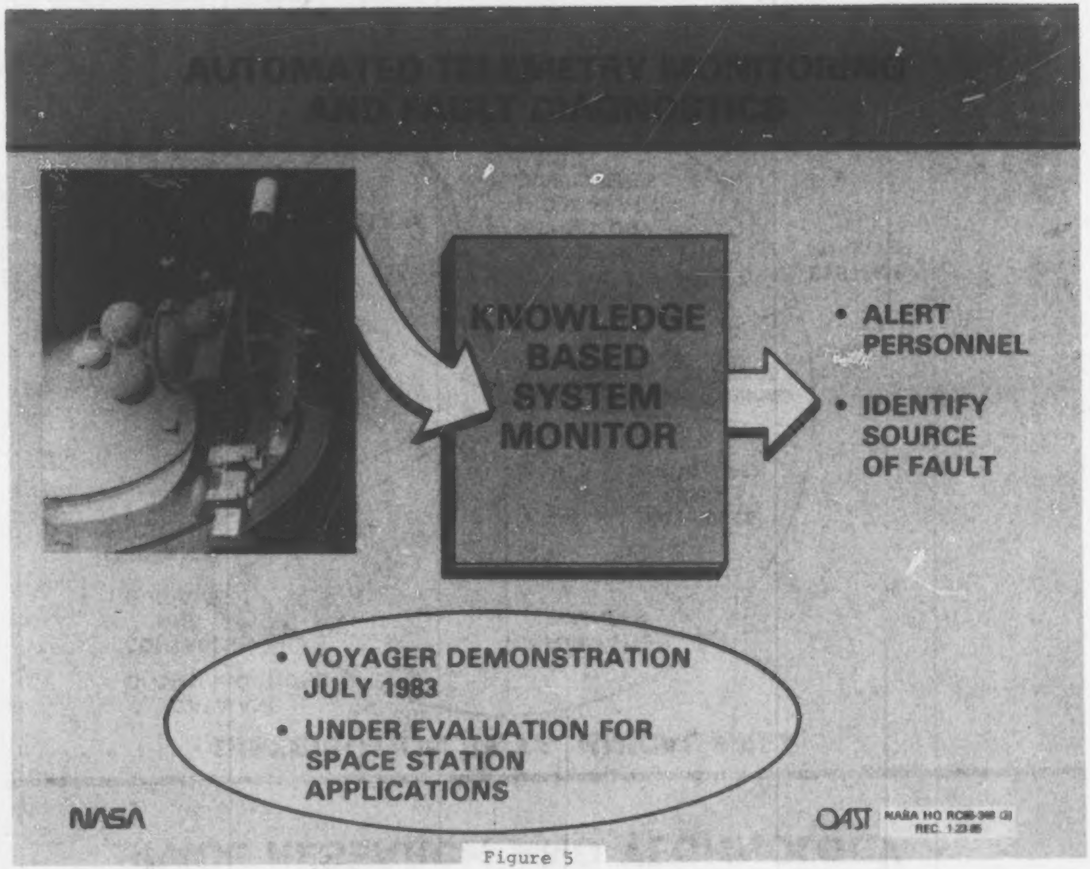
REV. 1-11-86



AUTOMATED TELEMETRY MONITORING AND FAULT DIAGNOSTICS

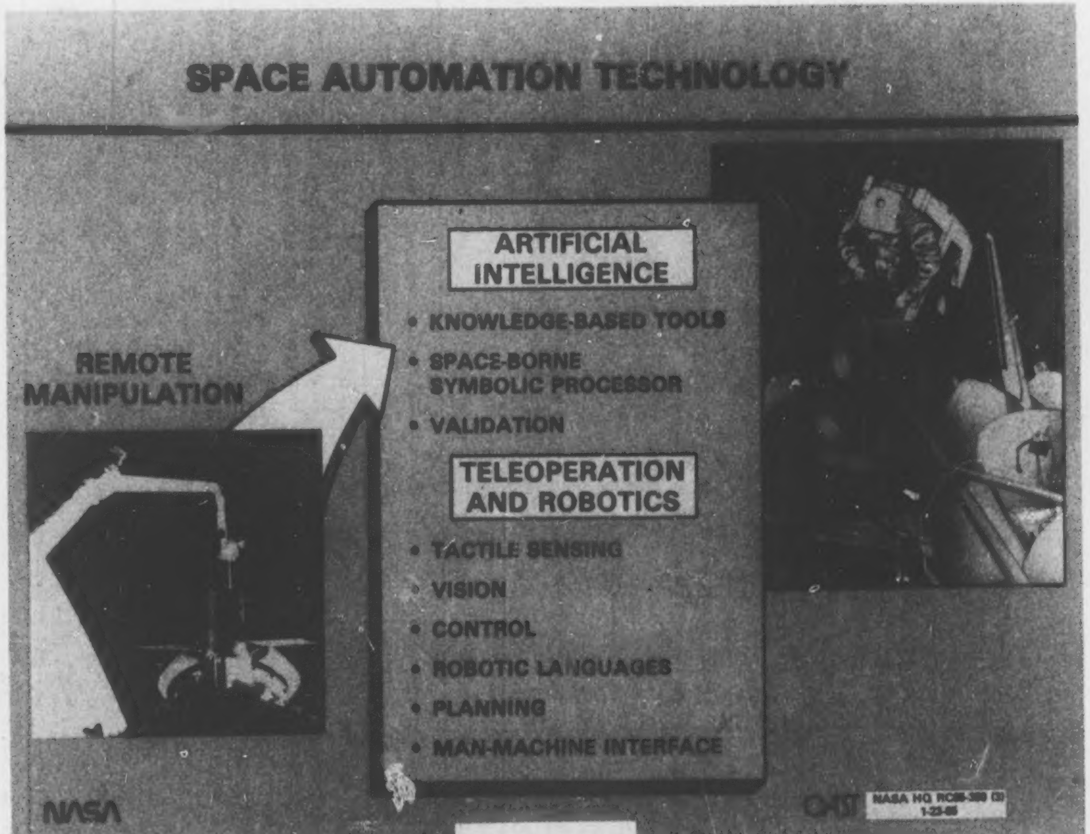
KNOWLEDGE BASED SYSTEM MONITOR

- ALERT PERSONNEL
- IDENTIFY SOURCE OF FAULT

- VOYAGER DEMONSTRATION JULY 1983
- UNDER EVALUATION FOR SPACE STATION APPLICATIONS

NASA
OAST
NASA HQ RC85-348 (3)
REC. 1-23-85

Figure 5



SPACE AUTOMATION TECHNOLOGY

REMOTE MANIPULATION

ARTIFICIAL INTELLIGENCE

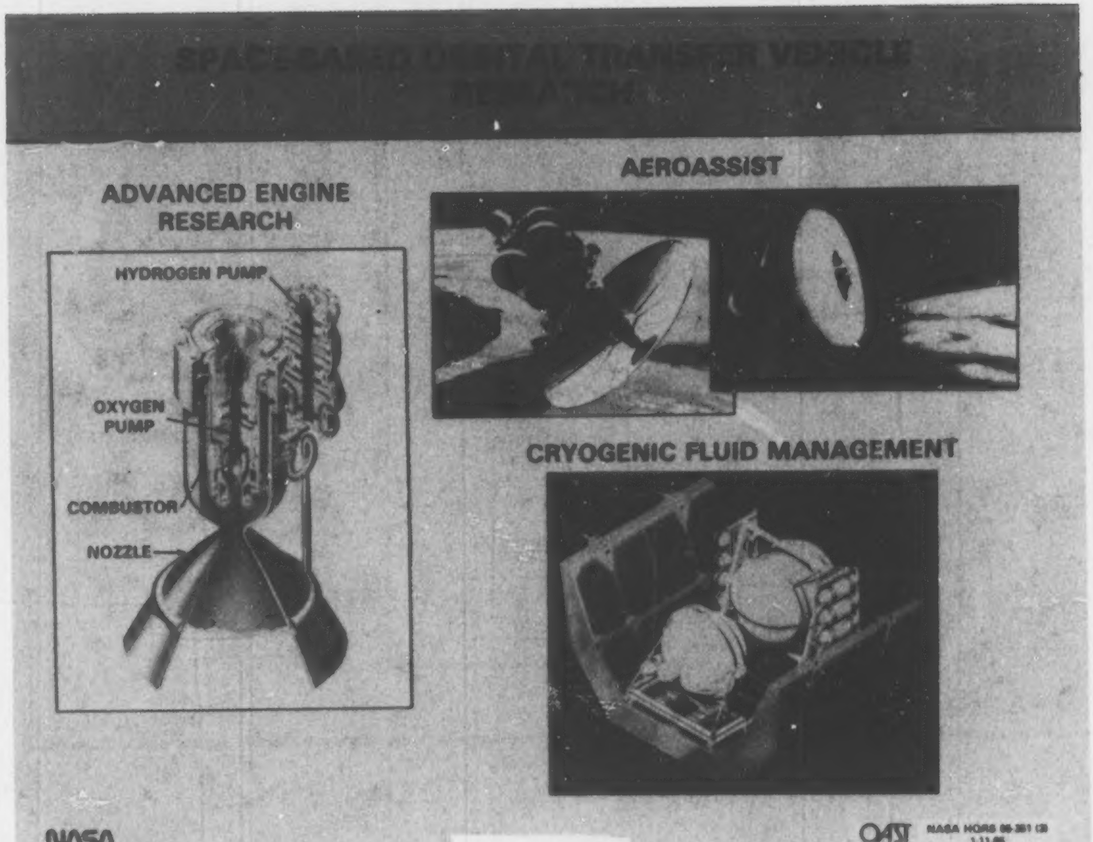
- KNOWLEDGE-BASED TOOLS
- SPACE-BORNE SYMBOLIC PROCESSOR
- VALIDATION

TELEOPERATION AND ROBOTICS

- TACTILE SENSING
- VISION
- CONTROL
- ROBOTIC LANGUAGES
- PLANNING
- MAN-MACHINE INTERFACE

NASA
OAST
NASA HQ RC85-380 (3)
1-23-85

Figure 6



SPACE-BASED ORBITAL TRANSFER VEHICLE RESEARCH

ADVANCED ENGINE RESEARCH

HYDROGEN PUMP
OXYGEN PUMP
COMBUSTOR
NOZZLE

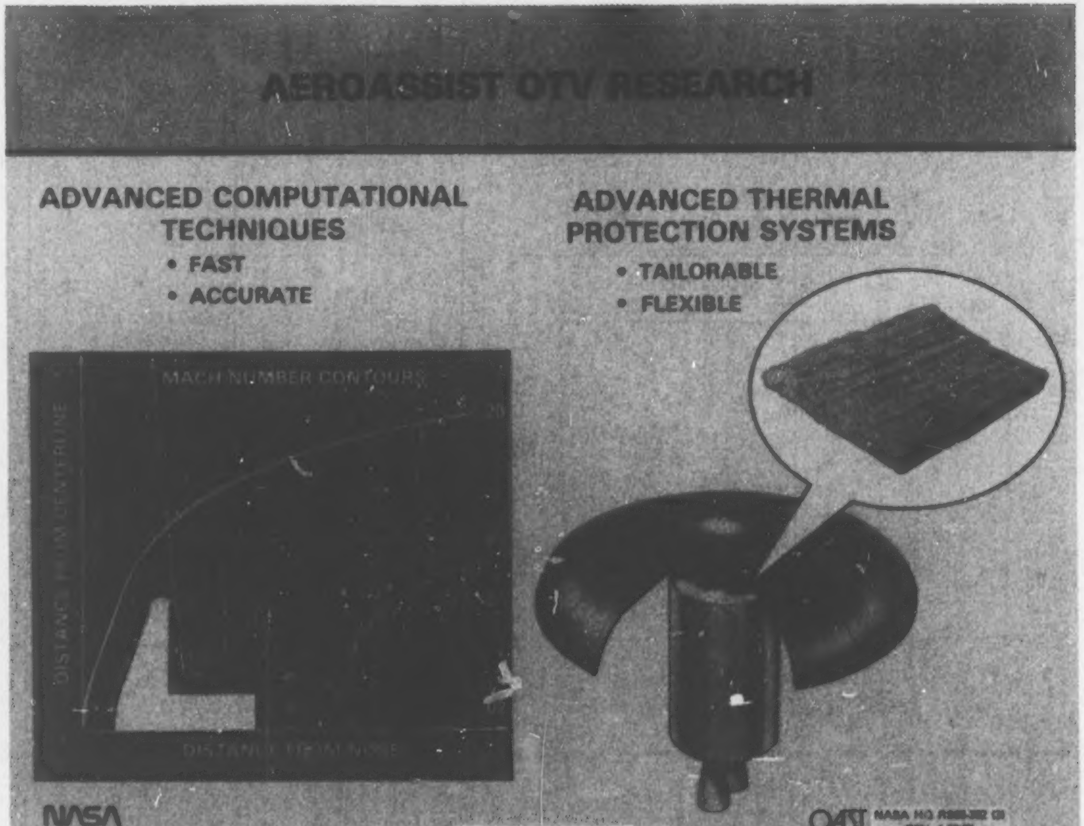
AEROASSIST

CRYOGENIC FLUID MANAGEMENT

NASA

OAST NASA HQRS 86-351 (3)
1-11-86

Figure 7



AEROASSIST OTV RESEARCH

ADVANCED COMPUTATIONAL TECHNIQUES
- FAST
- ACCURATE

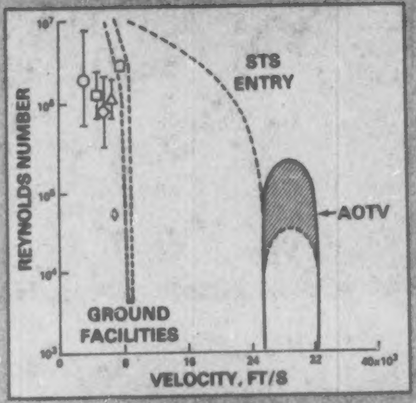
ADVANCED THERMAL PROTECTION SYSTEMS
- TAILORABLE
- FLEXIBLE

MACH NUMBER CONTOURS
20
DISTANCE FROM CENTERLINE
DISTANCE FROM NOSE
NASA
OAST
NASA HQ [illegible]
REV. [illegible]

Figure 8

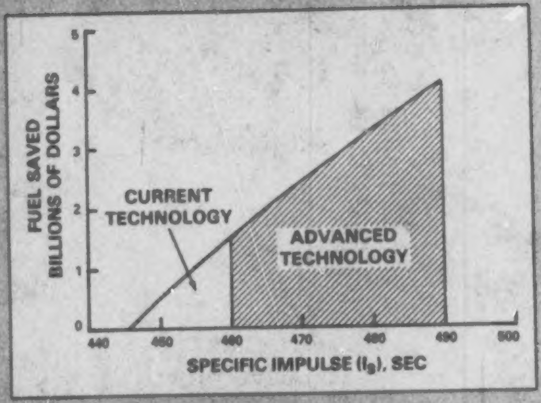
OTV TECHNOLOGIES

AEROASSIST FLIGHT EXPERIMENT



- VALIDATE ENVIRONMENT PREDICTIONS
- EVALUATE VEHICLE CONCEPTS

ADVANCED PROPULSION RESEARCH ENGINE



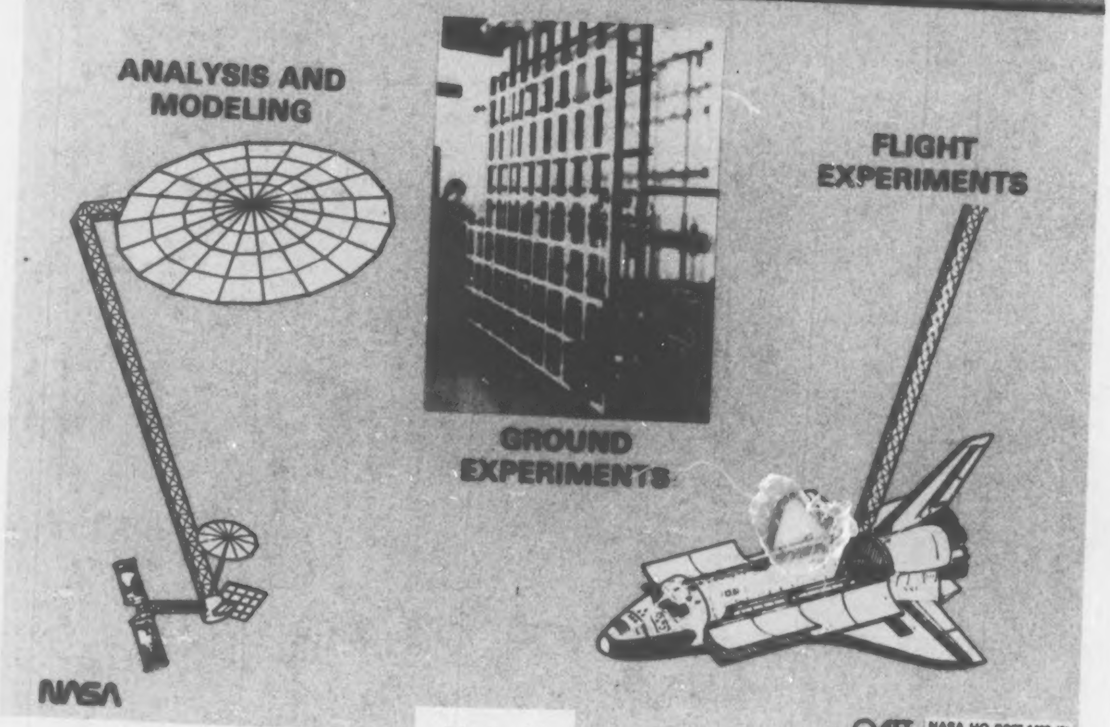
- COMPONENT TECHNOLOGY AND INTEGRATION

NASA

OAST NASA HQ RS85-383 (3)
1-23-85

Figure 9

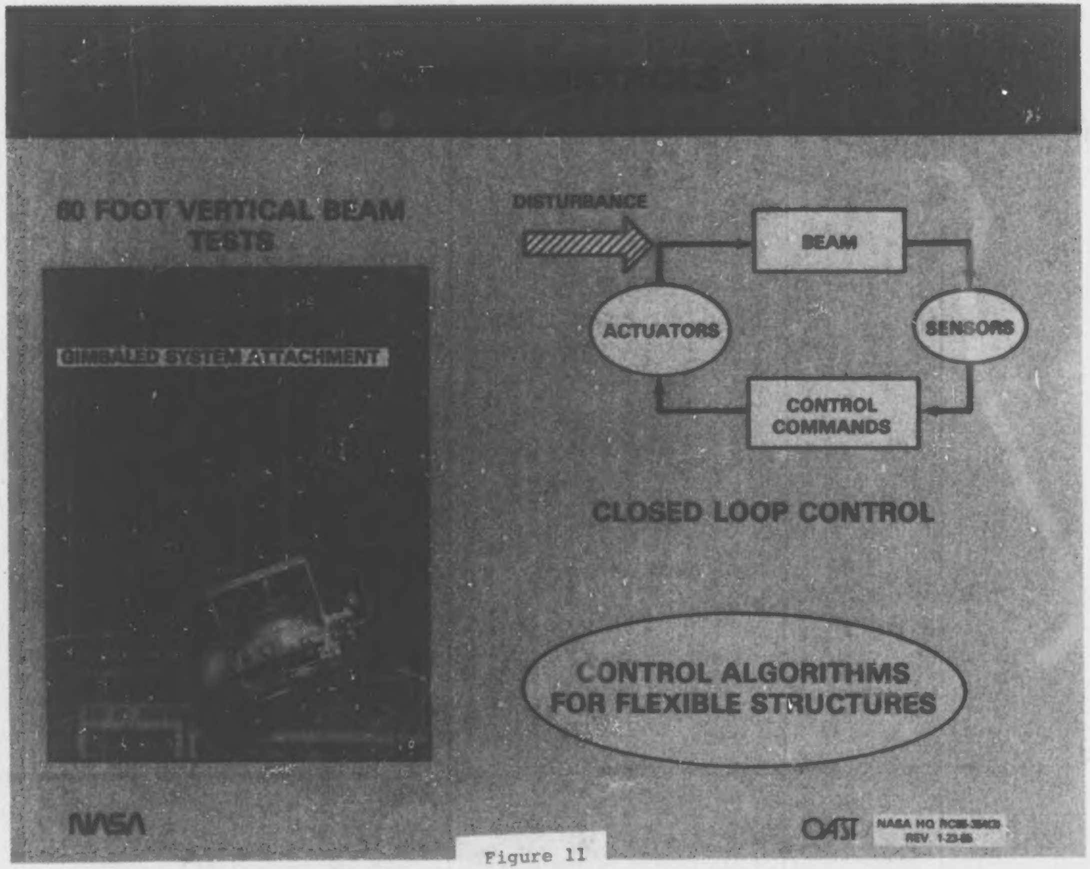
CONTROL OF FLEXIBLE STRUCTURES


ANALYSIS AND MODELING
GROUND EXPERIMENTS
FLIGHT EXPERIMENTS

NASA

OAST NASA HQ RS85-1482 (3)
REV. 1-23-85

Figure 10



60 FOOT VERTICAL BEAM TESTS

GIMBALED SYSTEM ATTACHMENT
DISTURBANCE
BEAM
ACTUATORS
SENSORS
CONTROL COMMANDS

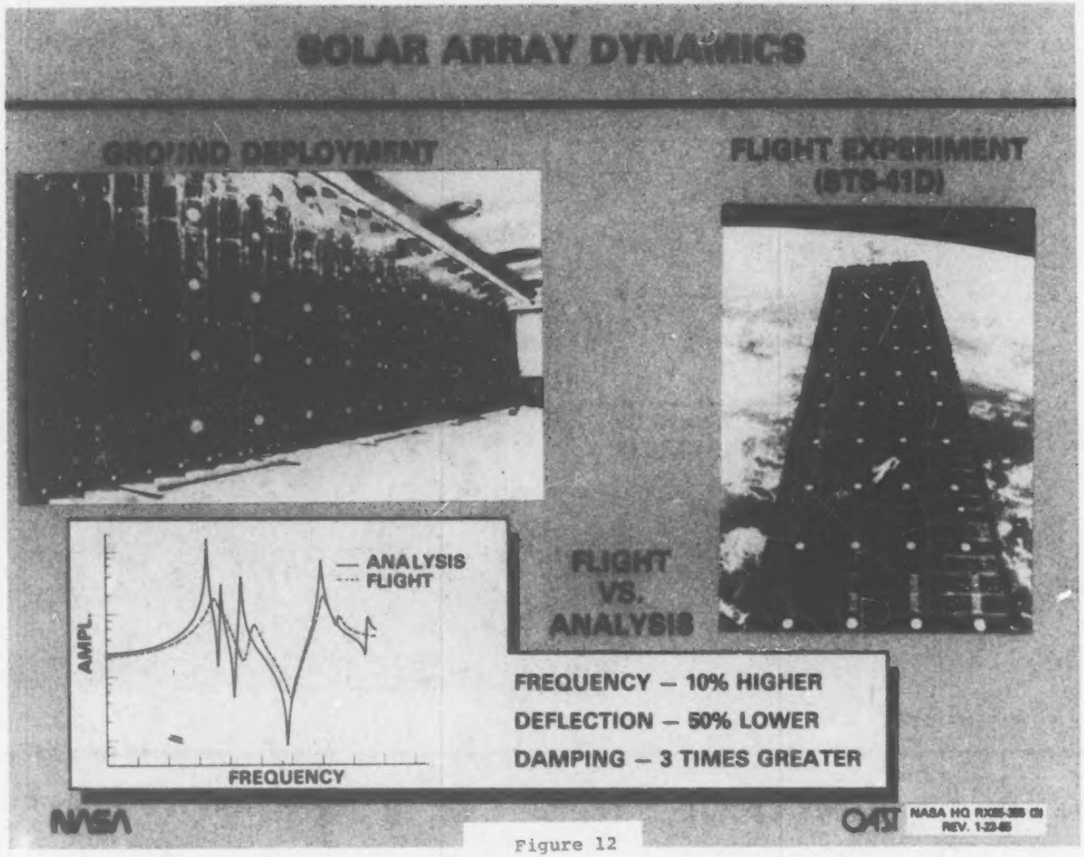
CLOSED LOOP CONTROL

CONTROL ALGORITHMS FOR FLEXIBLE STRUCTURES

NASA

OAST NASA HQ RC86-3943
REV 1-23-86

Figure 11



AMPL.
— ANALYSIS
--- FLIGHT
FREQUENCY

SOLAR ARRAY DYNAMICS

GROUND DEPLOYMENT

FLIGHT EXPERIMENT
(STS-41D)

FLIGHT
VS.
ANALYSIS

FREQUENCY — 10% HIGHER

DEFLECTION — 50% LOWER

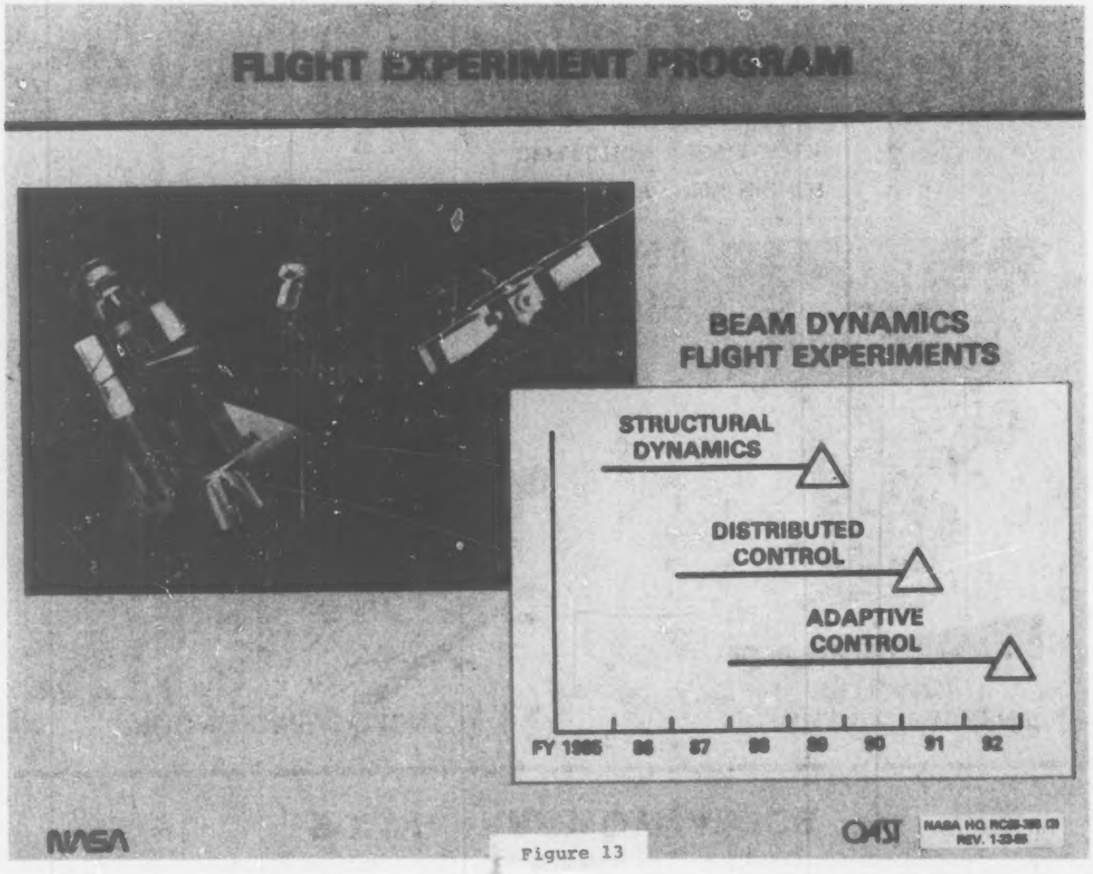
DAMPING — 3 TIMES GREATER

NASA

OAST

NASA HQ RX85-355 (3)
REV. 1-23-85

Figure 12



FLIGHT EXPERIMENT PROGRAM

BEAM DYNAMICS
FLIGHT EXPERIMENTS

STRUCTURAL
DYNAMICS

DISTRIBUTED
CONTROL

ADAPTIVE
CONTROL

FY 1985 86 87 88 89 90 91 92

NASA

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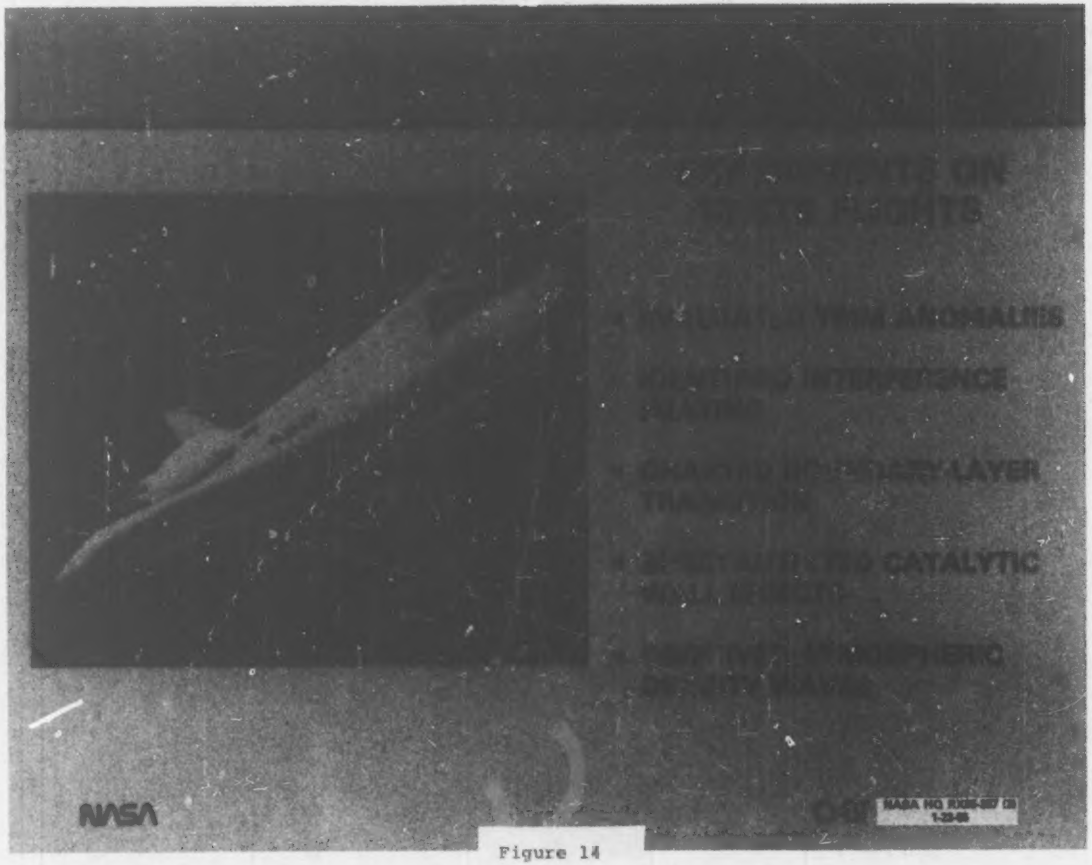
REV. 1-23-85

Figure 13

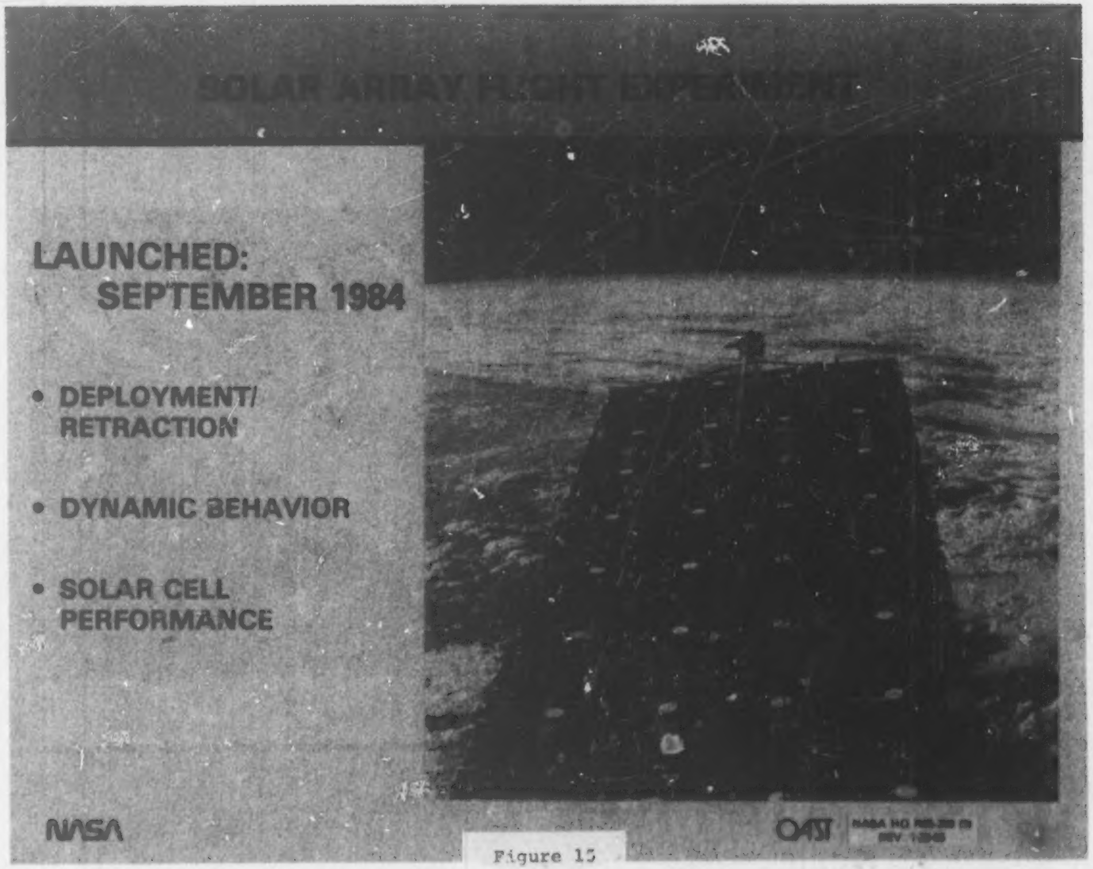


[illegible] ON [illegible] FLIGHTS

- [illegible] WITH ANOMALIES
- [illegible] INTERFERENCE HEATING
- [illegible] BOUNDARY-LAYER TRANSITION
- [illegible] CATALYTIC WALL EFFECTS
- [illegible] ATMOSPHERIC DENSITY WAVES

NASA
NASA HQ RX85-307 (3)
1-23-85

Figure 14



SOLAR ARRAY FLIGHT EXPERIMENT

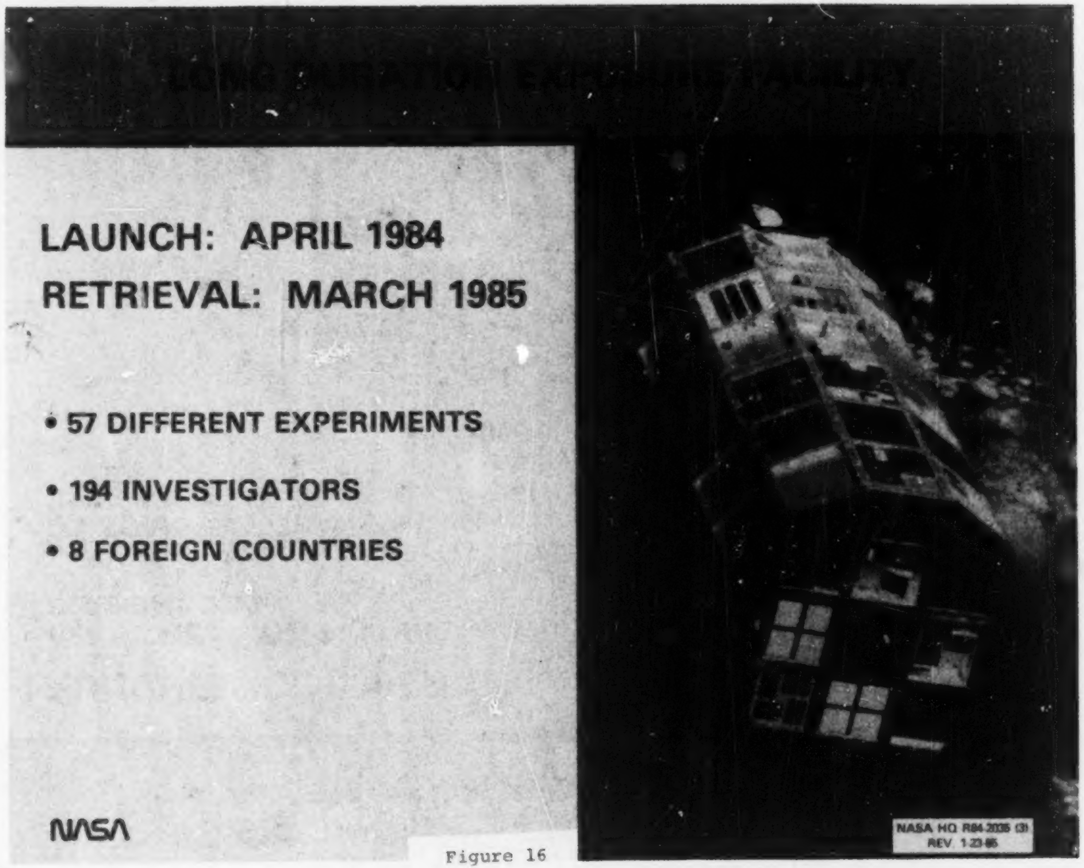
LAUNCHED:
SEPTEMBER 1984

- DEPLOYMENT/
  RETRACTION
- DYNAMIC BEHAVIOR
- SOLAR CELL
  PERFORMANCE

NASA

OAST | NASA HQ [illegible]
REV [illegible]

Figure 15



LONG DURATION EXPOSURE FACILITY

LAUNCH: APRIL 1984

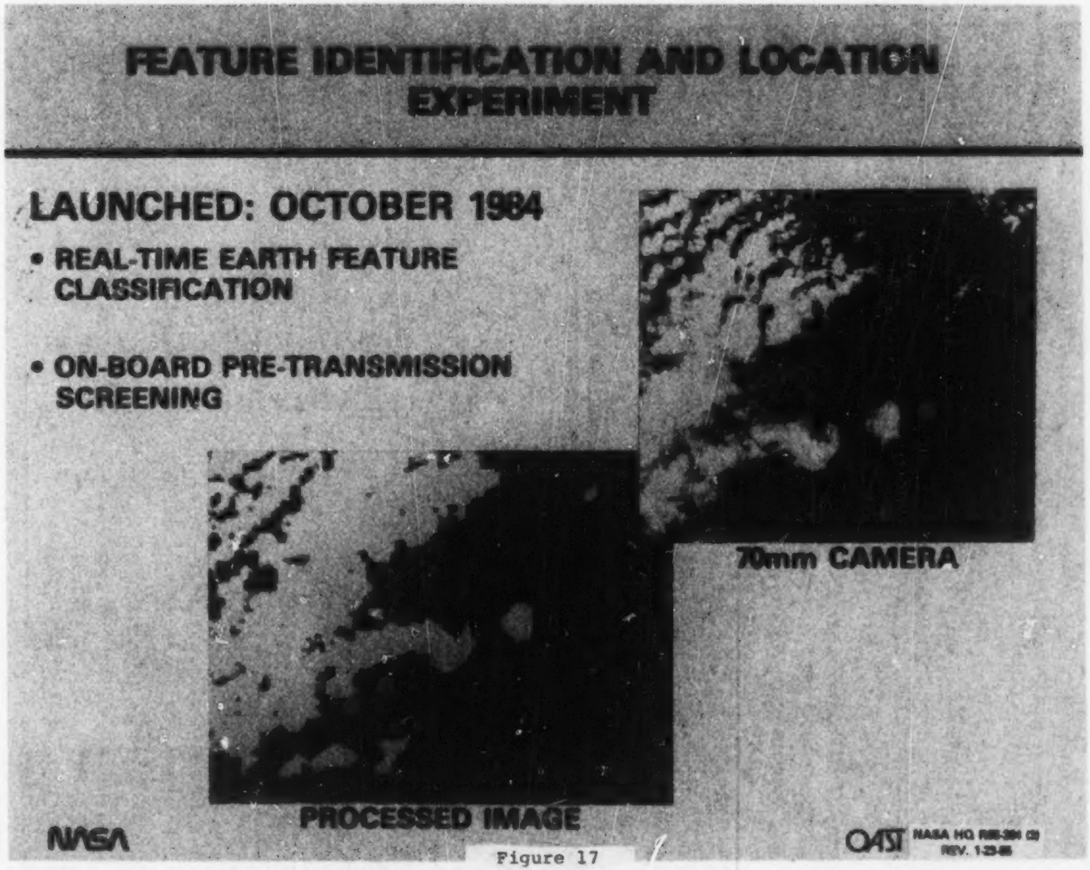
RETRIEVAL: MARCH 1985

- 57 DIFFERENT EXPERIMENTS
- 194 INVESTIGATORS
- 8 FOREIGN COUNTRIES

NASA

NASA HQ R84-2035 (3)
REV. 1-23-85

Figure 16



FEATURE IDENTIFICATION AND LOCATION EXPERIMENT

LAUNCHED: OCTOBER 1984

- REAL-TIME EARTH FEATURE CLASSIFICATION
- ON-BOARD PRE-TRANSMISSION SCREENING

70mm CAMERA

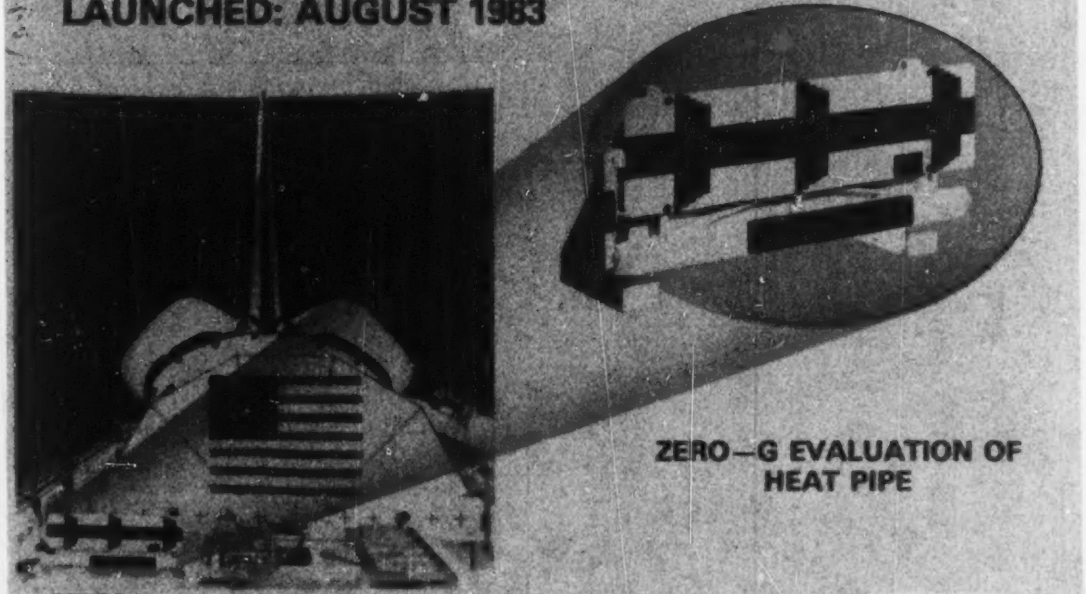
PROCESSED IMAGE

NASA
OAST
NASA HQ [illegible]
REV. 1-23-85

Figure 17

[illegible] CONTROL EXPERIMENT

LAUNCHED: AUGUST 1983

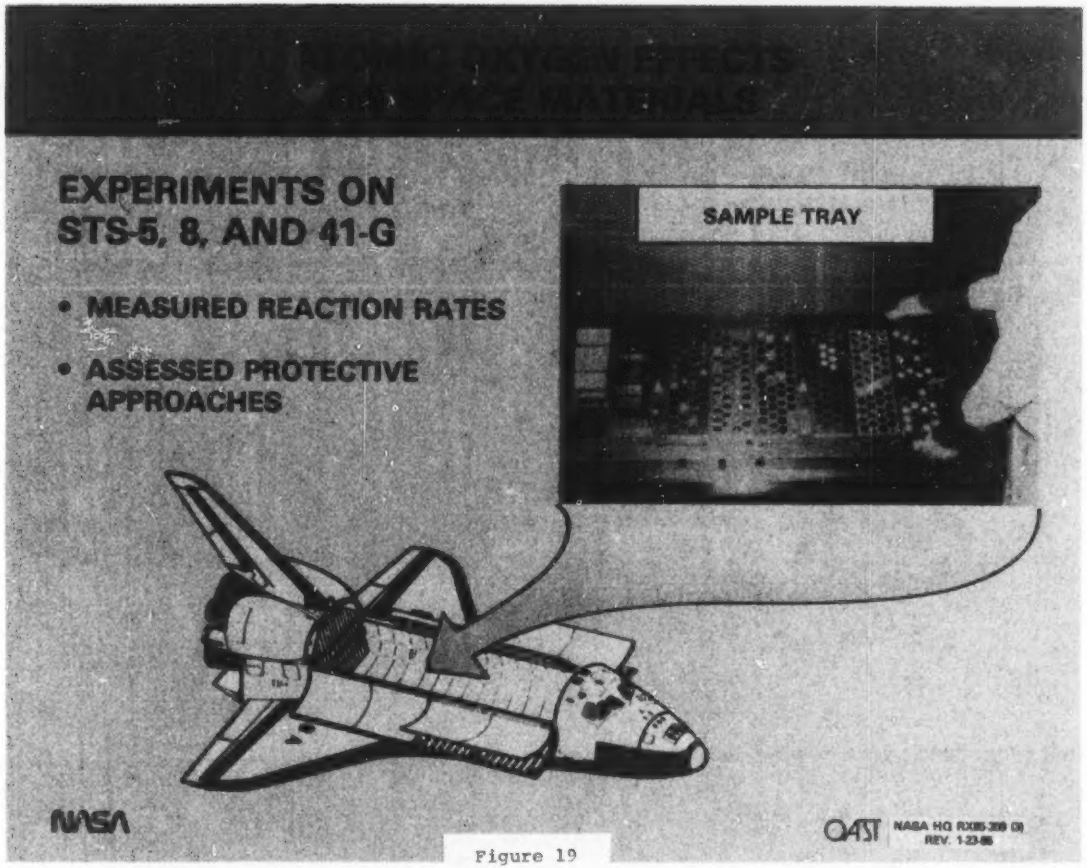


ZERO—G EVALUATION OF
HEAT PIPE

NASA

OAST NASA HQ [illegible]
REV 1-23-85

Figure 18



ATOMIC OXYGEN EFFECTS ON SPACE MATERIALS

EXPERIMENTS ON STS-5, 8, AND 41-G

- MEASURED REACTION RATES
- ASSESSED PROTECTIVE APPROACHES

SAMPLE TRAY

NASA

OAST | NASA HQ RX85-309 (3)
REV. 1-23-86

Figure 19

Questions submitted by Chairman Nelson during the February 28, 1985 hearing at which Dr. Martin testified.

QUESTION R-1:

Please explain the reason for the 176 percent (or $3.7 million) increase in funding between FY 1985 and FY 1986 for "Chemical Propulsion Systems Technology".

ANSWER R-1:

The Chemical Propulsion Systems Technology Program funding provides for the design, analysis, and fabrication of advanced cryogenic engine technology components that have been selected for verification testing under the Space Shuttle Main Engine (SSME) Technology Test Bed Program. This joint program with the Office of Space Flight uses a non-flight SSME as a test bed to develop a comprehensive technology base for advanced cryogenic engines, verified in a realistic engine environment. The increased funding in FY 1986 reflects the planned program funding profile and will initiate the fabrication of advanced bearings and diagnostic sensors for installation in the engine turbomachinery, and the design and fabrication of advanced longer-life turbine blades. FY 1986 initiation of these long lead-time items is necessary to ensure their availability as required by the program plan. The FY 1985 funding was primarily directed towards the procurement of advanced instrumentation which will be used to measure and to more fully understand the internal engine environment, and for initiating design and analysis efforts for the advanced bearings and turbopump diagnostic sensors - these tasks continue into FY 1986.

QUESTION R-2:

In your FY 1986 budget, you have added a new program activity -- "control of flexible structures". Please describe the purpose and scope of this program area.

ANSWER R-2:

The Control of Flexible Structures (COFS) Program will be focused on the development of technology required to understand and accurately predict and control deformations of large flexible spacecraft in a zero-gravity environment. The program includes major ground and on-orbit testing of increasingly complex structures to validate control/structures design methodologies, control methods, analytical tools and ground and flight test methods. The COFS plan schedules on-orbit testing to begin in 1989 and to have an initial validated control/structures technology data base ready in 1991.

Mr. NELSON. Thank you, Dr. Martin. About a year and a half ago almost 50 percent of your senior management positions were vacant, with acting people, you showed us the chart here, so why don't you share with us, for the record, as to your satisfaction that this situation has been stabilized?

Dr. MARTIN. It has been stabilized, Mr. Chairman, and we've gone a great distance. I think that the reason the situation was as it was a year ago was because it was clear that the organization that we had needed to be changed and rather than fill the positions we left them vacant while we decided what the new organization ought to look like. You've seen that organization now and we are well along on choosing people for the positions of responsibility in that organization. I showed you one vacancy on the chart remaining, that will be filled within the next month or so. There are about four or five other positions, which are vacant and three of those are—have recommendations made to Mr. Beggs, which will go before OPM as well and I expect that they will be filled within the next couple of months. There is one other that we have yet to make a recommendation to Mr. Beggs on, we will do that very shortly. So, I think that within a couple of months we will have our organization in place and it will be adequately staffed and performing the job that it needs to be done.

Mr. NELSON. Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman. As we look toward the commercial future, really towards the U.S. position in space, it seems to me that one of the chief issues we have to face, if not the chief issue in all of this is the cost per pound to orbit. As you are moving ahead with your experiments, to what extent are we seeking to lower those costs and what are your projections in terms of being able to lower those costs substantially?

Dr. MARTIN. I alluded sir, to some efforts we are making to improve propulsion with respect to OTV in particular. I think that those propulsion efforts that we're making are based on technologies which are applicable to space lift, as well as space maneuver. I can't tell you at this time what the savings might be in that respect, but we are pointed in that direction. We are making those efforts.

Mr. WALKER. Do we have any evaluation, at this point, as to how low it is technically feasible to take the cost to orbit?

Dr. MARTIN. I don't have any numbers. My associate, Dr. Colladay, is a propulsionist. Let me refer to him and see if he has some response to that.

Dr. COLLADAY. Well, I'm reluctant to give you a hard number, but I think from the technology—because we just don't know it at this point, but our studies in the advanced technology components in Earth to orbit engines that we're working on, would indicate that we could—we could substantially cut Earth to orbit costs. By substantial I mean in the order—on the order of 30 to 40 percent perhaps. There's a long—a long evolution that technology in propulsion has to go through, just as in air-breathing engines we see derivative engines follow in a family or a class of engines. We see the same future in shuttle main engine, where it will go through refinements and derivative versions that will substantially improve its performance.

Mr. **Walker**. That 30- to 40-percent reduction, in what timeframe are we talking about?

Dr. **Colladay**. I'd say in the 10- to 15-year range.

Mr. **Walker**. So, based upon what we now think we're capable of doing we can lower the cost 30 to 40 percent by the year 2000?

Dr. **Colladay**. Yes; I think we can in that——

Mr. **Walker**. Can it be done before that?

Dr. **Colladay**. I don't think it's technically feasible to accelerate it much beyond that. It's a very—the shuttle main engine, as you know, is an extremely complex piece of machinery and it takes a lot of advanced technology to advance it.

Mr. **Walker**. Well, I read recently, and this gets me more to the experimental side, I read recently that the Soviets are evidently in the process of developing a heavy-lift vehicle of some sort, but the prediction that was stated was that they are going to be able to lift to orbit 400 to 500 tons at a time that will give them an opportunity to put very, very heavy vehicles into orbit, which then will expand their capacity, for instance, to do space station work markedly and that they are projecting being able to put several hundred people into space stations, utilizing that kind of technology.

Now, it seems to me that if they develop that kind of technology that their cost to orbit will probably be substantially lower than anything that we can do. Is that a reasonable projection?

Dr. **Colladay**. Well, we're looking at both shuttle derived vehicles and large Earth-to-orbit launch vehicles in our technology program. In that mission driver that Dr. Martin showed earlier, you saw under transportation systems, a number of advanced heavy lift launch vehicles that would build on the technology that we're working on in OAST.

Mr. **Walker**. Will any of those get 400 to 500 tons to orbit?

Dr. **Colladay**. I believe the heavy-lift launch vehicle would be in that—in that class of launch vehicle, yes, and it would build on the main engine technology that we have in the orbiter now and on LOX hydrocarbon versions of advanced propulsion systems.

Mr. **Walker**. But, it would not cut the cost—the cost per pound to orbit substantially?

Dr. **Colladay**. The heavy-lift launch vehicle would, I believe, would cut the cost per pound to orbit, yes sir, it would.

Mr. **Walker**. Do we have any idea what that cost reduction would be?

Dr. **Colladay**. I don't, sir; we can provide that for you.

[The information follows:]

OAST has an aggressive technology program focused on reducing the launch and operations cost of space transportation systems. The technology program supports both near term or evolutionary advances in current systems as well as technology for next generation systems.

For the near term (mid to late 1990's), NASA has studied the feasibility of shuttle derived systems, using existing or growth elements of the current Space Transportation System, which are capable of placing up to three hundred thousand pounds into low earth orbit. Shuttle derived systems hold the potential of reducing launch costs by a factor approaching two to three.

In the long term, post 2000 timeframe, the OAST technology program in advanced vehicle concepts, materials and structures, thermal protection systems, aerodynamics and aerothermodynamics, advanced propulsion, and automation technologies provide options for fully reusable systems with launch costs projected to be an order of magnitude lower than today.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. NELSON. Ms. Meyers.

Ms. MEYERS. No questions.

Mr. NELSON. Mr. Smith.

Mr. SMITH. No questions.

Mr. NELSON. Mr. Andrews.

Mr. ANDREWS. No questions.

Mr. NELSON. Let me ask you, Dr. Martin, what is the possibility that the material that's been developed for NASA in the TPS, thermal protection system, particularly the blankets, might be employed, incorporated into use by firefighters as a part of their protective gear?

Dr. MARTIN. Mr. Chairman, I suspect that the cost of those materials is very high, compared to what firefighters normally would be able to spend for such equipment. That is, I suppose, because the amount of such material that are manufactured are small because the needs are small. I think it would be worth our taking a look to see what the possibilities are and reporting back to you on that, but I'm sure that it would be an expensive proposition until such time as such material was adopted widely and there was a good deal of the thermal protection system material manufactured for that purpose rather than space.

Mr. NELSON. Well, I would like you to submit that in writing. We will make it a part of this record. One of the strong points of NASA is its technology transfer. The fantastic developments for our space technology and how we can apply them to everyday life. And as you and I have discussed previously, in a private conversation, NASA must continue to be mindful that when in fact it can develop these fantastic things that affects our daily lives, such as kitchen appliances and materials that we wear and microelectronics, and our computers, and so forth, pacemakers, modern miracles in medicine, that NASA needs to learn how to crow about that. And NASA perhaps needs some help from those of us who live in the public world and so I was sitting down with a friend of mine, who happens to be a firefighter as an advocation, and it suddenly started dawning on me, here we've developed a material, certainly expensive at this point, but a thermal blanket that's very lightweight and that can withstand up to 2,000′ of heat. And we might just see application of those kinds of thing. To many things, the first thing that came into my mind was my conversation with my friend about the increasing demands on firefighters in today's environment. Going into closed buildings, high buildings, new kinds of fumes, and smoke, and so forth. And so I wish you would report——

Dr. MARTIN. We'll take that task and report back to you.

[The information follows:]

NASA's thermal protection technology has in the past been transferred to firefighters. A firefighter protective ensemble was developed from Apollo technology under a contract awarded to Grumman Aerospace Corporation in March 1977. The ensemble weighs about half as much as the old uniform, costs about $600 per fireman, and improves both the performance and protection of firefighters. Eighty-five ensembles are currently being tested in actual use in 14 cities under the auspices of the International Association of Firefighters.

Presently there has been no interest expressed for adapting Shuttle thermal blanket technology to advanced protective outfits. Based on current test results, the en-

semble has set the requirements initially stipulated. The thermal blanked technology, however, has been transferred to other non-aerospace applications.

Johns-Manville Corporation is now manufacturing the blanket materials, which they originally developed for the Shuttle under the trade name "QUILLITE." The automobile industry is studying it for application as a thermal insulation material for hood liners and exhaust systems in high performance race cars. Additionally, the Navy is considering the material for shipboard insulation to protection bulkheads and ordnance from high heat levels of onboard fires.

Mr. NELSON. This might just be another fantastic development of NASA that might have a new application.

All right. Now, what is the status of your ion propulsion research?

Dr. MARTIN. The proposition for fiscal year 1986, sir, is to support ion propulsion in-house at the level of $440,000 at Lewis Laboratory. That will effectively stop all work in industry and in addition to the ion propulsion work I think there's about $2.5 million in electric propulsion, which one should differentiate, but which is related in some way. So, we are cutting out the out-of-house work and maintaining a base in-house at the level that I've stated.

Mr. NELSON. All right. The solar system exploration committee had highlighted ion propulsion and said that it should be nurtured because of its potential importance to future planetary, perhaps asteroid missions. Does your current funding plans, are they or are they not in keeping with the spirit of those recommendations?

Dr. MARTIN. They are, although it might not appear so, Mr. Chairman. There was a lot of hand ringing on my part, and some others who are associated with me, about the need to do what we are proposing to do. We counseled with the Office of Space Science and Applications because they would be the user of such a capability and it developed that the technology is really ahead of schedule, so to speak, for its utilization by about 4 or 5 years, at the least, and probably closer to 10 years before we would get to using it and it seemed prudent to back off from such support as we were giving it and to put it at a level we could afford to maintain in-house for awhile, because it's probably not till 1988 or 1990 that we would go forward and ask for some assistance, in that respect, with ion propulsion. So it was strictly an economic decision, one of feeling that we had better use for the dollars for the time being and that was the basis behind it. I think that there was a concensus between the users and ourselves on that.

Mr. NELSON. All right. Does the planetary research community concur with your ion propulsion funding proposal?

Dr. MARTIN. To the degree that the Office of Space Science and Applications has a large and vocal advisory structure, which represents that community and the Office of Space Science and Applications has informed us, concurred with us, as they have, I assume that they are representing that community. I have not dealt with it directly, but I presume that they are speaking for that community when they said the things to us that they did.

Mr. NELSON. OK, let's talk about something else. What is the current status of the SP-100 nuclear power program?

Dr. MARTIN. To go back a little, we got into an agreement with the Department of Energy and the Department of Defense on that in 1983 to advance and to evaluate the technologies which might permit space power at the 100-kilowatt level. That's been going on, with an expectation of reaching a decision point on one of three options in July this year and we're on schedule to do that. Following that decision of which concept of the three would be used, we would go into a ground engineering systems phase, which would begin later on in 1985, so I think it's on track and that it's going well.

Mr. **Nelson**. OK, what's the likely impact on the SP-100 program of the recent switch in the defense participation from DARPA to the SDI Office?

Dr. **Martin**. Little or none. DARPA was representing SDI Office interests, as well as others, during its participation. We have had one meeting with the representative of the SDI, Lieutenant General Abrahamson, on the SP-100 program, and the only difference I could sense is that his requirements are much more defined than they had been previously thought of. For one, and I think he had a sense of assuring lack of vulnerability that had not been quite so stressed as previously, but in essence I would say that there's been little difference in that change.

Mr. **Nelson**. Is the fact that it's being located in the SDI, in your opinion, is that going to politicize it? And thus, is it going to make it more difficult, politically, to move?

Dr. **Martin**. That's a value judgment, Mr. Chairman. It hadn't occurred to me that it would make it more difficult. I think there is a large community that supports SDI and will support the elements of technology and systems work that it is doing, so I would anticipate no problem, and I hope there is none.

Mr. **Nelson**. OK, now as a follow-on to that, since the initial applications of the SP-100 program are going to be to the military what should be the continuing level of NASA's support for this program.

Dr. **Martin**. We think that support should be the level at which we've put it in for fiscal year 1986 and I think that was $4 million?

Dr. **Colladay**. Yes.

Dr. **Martin**. $4 million in 1986. We expect to continue to play a role in the nonnuclear technology development of such a system as that. In addition to our money support, dollar support, we support with researchers at Lewis Research Center in Cleveland, so I think that it will go ahead on the civil side just as it had in the past. I don't expect any deviations from that.

Mr. **Nelson**. And what's your level you're expecting for 1987?

Dr. **Colladay**. About the same level.

Dr. **Martin**. Is it about the same?

Dr. **Colladay**. Yes.

Mr. **Nelson**. All right. What do you think about the conclusions reached by the NASA civil missions advisory group regarding the likely civil applications for nuclear electric power?

Dr. **Martin**. I've read that report and I subscribe to what they had to say. I think that it will be the mid-1990's at the earliest, and probably later than that that the kind of levels of power that SP-100 can bring forth will be required in space, so that I think they were right on track and I think that we are working in a direction that keeps us playing a part that will let us exploit when the time comes to do so.

Mr. **Nelson**. As you know, with my budgetary background I have an interest there, so let me ask you a budget question.

Part of your budget for standards and practices, you have a 63-percent increase in your request this year over last year. Why?

Dr. **Martin**. There are two elements to that. There is one, a recognition that nondestructive evaluation is a technique and a capability that NASA requires to a much greater degree than it had realized in the past and so some of the increase is due to that. Another part of the increase is attributable to an aggregation of several interests in NASA for—and understanding of the radiation effects on microelectronics in space. And that aggregation has made it desirable to support that kind of analysis and experiment more than it had been in the past, so fundamentally those two aspects, microelectronics and space vulnerabilities to radiation and nondestructive evaluation.

Mr. **Nelson**. Any of the members of the committee have any further—Mr. Volkmer.

Mr. **Volkmer**. I have no questions.

Mr. **Nelson**. OK, thank you, Dr. Martin.

Dr. **Martin**. Thank you, Mr. Chairman.

Mr. **Nelson**. Appreciate it. It was a pleasure to visit with you yesterday and again today formally.

Dr. **Martin**. Thank you.

Mr. **Nelson**. Enjoyed it.

OK, Mr. Gillam.

You are welcome to bring up your assistant directors, if you like. OK, why don't you proceed and congratulations again on your post.

STATEMENT OF ISAAC T. GILLAM, ASSISTANT ADMINISTRATOR FOR COMMERCIAL PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY FRANK PENARANDA, DEPUTY ASSISTANT ADMINISTRATOR (PROGRAMS); GARY KRIER, DIRECTOR, COMMERCIAL DEVELOPMENT; PETER EATON, ACTING DIRECTOR, PLANS, POLICY AND EVALUATION DIVISION; JOE KRATOVIL, DIRECTOR OF PROGRAM SUPPORT; STUART EVANS, OFFICE OF PROCUREMENT; AND GARY TESCH, OFFICE OF GENERAL COUNSEL

Mr. **Gillam**. Thank you very much, Mr. Chairman.

Mr. Chairman, I appreciate this opportunity to speak on the fiscal year 1986 budget for the NASA Office of Commercial Programs. Our funding request for $30 million will support research and development—the research and development initiative contained in the Administration's National Commercial Space Policy, and implement NASA's commercial use of space programs. Our funding request for $11.1 million will continue NASA Technology Utilization Program.

Since this is my first opportunity to testify since the establishment of the Office of Commercial Programs, my remarks will focus primarily on those activities which are being initiated in the fiscal year 1985, in accordance with our request to Congress in December and our planned approach to encouraging the commercial use of space.

I'd like to take the opportunity, briefly, Mr. Chairman, to introduce you with some of the senior—to some of the senior staff of the Office of Commercial Programs, who are present with us today.

First, I'd like to introduce Mr. Frank Penaranda, who is the Deputy Assistant Administrator for Programs, Mr. Gary Krier, who is the Director of the Office of Commercial Development; Mr. Peter Eaton, who is the Acting Director of the Plans and Policy Division; Mr. Joe Kratovil is also present, who is the Director of our Program Support Division. And, at the request of the committee, Mr. Chairman, we have also brought along Mr. Stu Evans from the Office of Procurement and Mr. Gary Tesch from the Office of General Counsel.

Our office is moving expeditiously to involve the private sector to the greatest extent possible in the exploration of space through effective utilization of the available to do, such as the space transportation system and other existing NASA capabilities, as well as future capabilities, such as the space station.

NASA's fiscal year 1986 commercial programs budget has been developed to encourage commercial use of space in two broad areas, commercial development and technology utilization. I will be describing the fiscal year 1986 budget request for the TU program later in my testimony. We at NASA view the TU program and our commercial development efforts as complementary. I will describe some of our commercial program initiatives for which funding has been requested for fiscal year 1986.

Mr. Chairman, we plan, through a partnership of industry, Government and universities, NASA centers for commercial development of space that will help stimulate the basic research that will provide the fundamental knowledge, which will form the basis for new commercial ventures in space. While the Government will provide some funding to stimulate the development of these high-technology basic research ventures, an investment of resources on the part of the private sector is necessary for the centers to become self-sustaining in 5 years. NASA plans to fund three to six of these centers at a rate of $½ million to $1 million per center beginning in fiscal year 1985. We're primarily interested in research and electronic materials, metallic alloys, glasses and ceramics, biological materials and in fluid dynamics. NASA recently established a NASA advisory council task force for the commercial use of space. This task force is chaired by Dr. Thomas A. Vanderslice. It is comprised of executives representing nonaerospace companies. The Vanderslice committee is taking a close look at the possibilities for nonaerospace industry participation in NASA research. The use of advisory panels with an emphasis on nonaerospace participation is, we believe, an effective mechanism for providing private sector input into NASA's research agenda. Perhaps the greatest barrier to undertaking a commercial space venture is the large capital costs associated with doing basic and applied research. The greatest driver of these capital costs is the development or acquisition of facilities and/or equipment. NASA is seeking to enable industry and the university researchers to consider space flight experimentation without prohibitive major investments and highly specialized equipment by making available Government facilities and equipment in the same manner that the NASA aeronautics facilities are available to industry. NASA hopes to stimulate potential private sector commercial research through a combination of Government funding and private resources with a focus on the commercial potential of materials processing, especially within the non-aerospace community. This initiative is intended to stimulate entrepreneurial and university involvement in space research with the greatest commercial potential, while increasing the number of scientists and engineers involved in research activities.

As with many other commercial space proposals that NASA has received from the private sector, two key evaluative criteria will be applied. The degree of risk being assumed by the private sector and the potential benefits that will accrue both to the space program and to the Nation.

NASA Administrator, Mr. James Beggs, has directed those of us in the Office of Commercial Programs, to fund only those projects which can demonstrate a commitment of resources on the part of the private sector. As such the Commercial Development Division, in reviewing commercial space projects submitted by NASA field centers, will seek the maximum leverage of Federal funds with private resources.

Over the last 25 years NASA has developed a unique working relationship with the aerospace community. In an effort to do the same with companies outside the aerospace community we will begin an outreach program to establish a dialog with universities and those potential private sector clients to gain an understanding of their key problem areas and to mutually determine how space research can be of assistance. The outreach program will cut across both the commercial development and technology utilization functions within the Office of Commercial Programs.

As important as it is to reach out to universities in the private sector to stimulate commercial space research, it is equally important to establish a dialog with those companies who may benefit from the applications of existing NASA developed technology. NASA's Technology Utilization Program funding request is $11.1 million for fiscal year 1986. The TU Program, with its focus on dissemination and application of existing technology, derived from NASA research, will continue its previous role with expanded responsibilities in the commercial use of space and space technology.

The Technology Utilization Program is designed to stimulate wide-scale transfer and secondary use of aerospace derived technology throughout the Nation's economy. We believe that the many beneficial uses resulting from NASA's tech transfer efforts in the past have been significant and fully justify a continued emphasis which the Congress and NASA have placed on this important activity. Over the past 2 years NASA has been moving steadily forward in its dissemination systems. As reported to this committee last year, systems improvements in support of NASA's industrial applications center network, including remote interactive search systems, high-speed computer search capabilities, and the expanded use of electronic mail as a delivery mechanism are continuing to be enhanced in our 1986 request.

Through our 1986 budget request we will strengthen NASA's technology transfer and dissemination methods employed by the NASA industrial application centers. A primary focus of NASA's efforts to encourage the commercial use of space is on new high technology ventures that create new wealth, new technology and increased economic activity. A key NASA barometer of private sector interest in these new hi-tech ventures is the number of proposed agreements submitted by private companies. Mechanisms such as joint endeavor agreements have been used by NASA as a way to facilitate the demonstration of commercial applications of space technology through a NASA industry partnership. Under a joint endeavor agreement there is no exchange of funds between NASA and the private sector, rather a quid pro quo is established whereby in exchange for a flight or flights aboard the space shuttle, and/or other services, a private company will structure the experiment, build the hardware, package the experiment, and share with NASA the experimental results.

The Office of Commercial Programs has been established as an agency wide focal point for the commercial use of space. NASA field centers have also been established at points of contact to expedite review and maintain commercial agreements. Every step will be taken by NASA to avoid stifling private sector innovation and creativity by overly cumbersome approaches to proposal evaluation.

Recent experience does suggest that when NASA and a private company work cooperatively to establish a commercial space agreement the NASA system is indeed very responsive. The 3M Corp. and NASA entered into a memorandum of agreement covering a joint space based materials research program in February of 1984. 3M's diffusive mixing of organic solutions experiments flew on shuttle mission 51-A, less than 9 months after the original agreement was signed.

For the next few minutes I'd like to briefly describe some of the ongoing NASA activities and mechanisms that are also contributing to the goal of expanding the level of private sector investment in space. For example, the Small Business Innovation Research Program represents an ongoing NASA program that can be particularly useful in increasing the number of companies pursuing commercial space ventures. Using the procedures and practices of the SBIR Program, the Office of Commercial Programs hopes to stimulate the involvement of small businesses in space research activities.

NASA has also been proceeding with the necessary steps to transfer the operation of the Delta, Atlas/Centaur, and Scout expendable launch vehicles to the private sector, in accordance with national policy and the recently enacted Commercial Space Launch Act. The Office of Commercial Programs will serve as a focal point for providing support to the Department of Transportation in carrying out its lead agency responsibilities and for commercial ventures associated with elements of the space transportation system.

The success of NASA's efforts to stimulate private sector involvement in space activities is critically dependent on the quality of the working relationship between the Office of Commercial Programs and NASA's other program offices. A close working relationship has been established with each program office to avoid duplication of effort and to insure the smooth integration of both our activities.

For example, our office and the space station office are both new offices, which share the goal of developing a permanently manned space station that both stimulates and supports commercial endeavors in space. Our relationship with the space station office is a positive one. The Space Station Program places heavy emphasis on mission or payload requirements and we can be assured, I believe, of the program having a strong commercial dimension. The Office of Commercial Programs stands ready to assist the private sector in pursuit of commercial endeavors. Some of the major challenges NASA will face in carrying out this mission involve developing an adequate microgravity research data base, reaching out to the non-aerospace entrepreneurs and assuring affordable access to space.

Mr. Chairman, the support of this committee in focusing on commercial space issues has been appreciated and we look forward to building on this established relationship in the future. This completes my prepared statement and I'd be pleased to answer questions at this time.

[The prepared statement plus answers to questions asked of Mr. Gillam follow:]

Statement of

Isaac T. Gillam IV
Assistant Administrator
Office of Commercial Programs

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

We welcome this opportunity to testify on the Fiscal Year 1986 budget request of NASA's Office of Commercial Programs. Our funding request for $30.0 million will support the research and development initiative contained in the Administration's National Commercial Space Policy and implement NASA's Commercial Use of Space program. Our funding request for $11.1 million will continue the Technology Utilization Program.

As this is our first opportunity to testify since the establishment of the Office of Commercial Programs, my remarks will focus primarily on those activities which are being initiated in FY 1985 in accordance with our request to the Congress in December and our planned approach to encouraging the commercial use of space.

In announcing the establishment of the Office of Commercial Programs this past September, NASA Administrator Mr. James Beggs stated that the Office "will provide a focus for efforts within NASA to expand U.S. private sector investment and involvement in civil space-related activities." The creation of the Commercial Programs Office and issuance of NASA's Commercial Use of Space Policy have demonstrated NASA's continuing commitment to opening the frontier of space to private enterprise. The Office of Commercial Programs is moving expeditiously to involve the private sector, to the greatest extent possible, in the exploitation of space and its resources through the effective utilization of the available tools, e.g., the Space Transportation System and other existing NASA capabilities, as well as future capabilities such as the Space Station.

NASA's FY 1986 Commercial Programs budget has been developed to encourage the commercial use of space in two broad areas: Commercial Development and Technology Utilization. Many of you are familiar with the Technology Utilization (T.U.) Program, but may not be aware that the T.U. Program is now being administered by the Commercial Programs Office. I will be describing the FY 1986 budget request for the TU Program later in my testimony, but let me assure you from the outset that there has been no reduction in Agency commitment to the T.U. Program or its mission.

In the Commercial Development area, the FY 1986 funding is required to pursue the following initiatives:

Centers for the Commercial Development of Space:

Stimulating the science and research communities to accelerate the process of moving ideas developed through basic research into the marketplace is a basic goal of this program. One method for facilitating the movement of technology from the laboratory to the marketplace has been demonstrated through a partnership of industry, Government, and universities in the establishment and operation of joint research centers. The NASA Centers for the Commercial Development of Space will help to stimulate the basic research that will provide the fundamental knowledge which will form the basis for new commercial ventures in space. In these Centers, the private sector will play a critical role in defining the R&D agenda that will have the best potential for commercial payoffs. These Centers will focus on a wide array of technology research areas. The Government would provide some funding to reduce the private sector financial risks for these high technology basic research ventures, but an investment of resources on the part of the private sector is also required and the Centers must become self-sustaining within five years.

NASA plans to provide seed-money for three to six Centers for the Commercial Development of Space at a rate of $500,000 to $1 million per Center per year beginning in FY 1985. At a "discussion conference" recently held at NASA Headquarters, we explained to over 200 attendees from industry, universities, and other Government agencies our requirements for strong industry and university participation in this program. Potential research areas that were discussed included: electronic materials, metallic alloys, glasses and ceramics, biological materials, and fluid dynamics.

Stimulating NASA Research with Commercial Potential:

The growing awareness, stimulated by the Space Shuttle, of the unique attributes of space as a research environment has created the opportunity for greater industry involvement in space R&D activities. Through greater industry involvement in setting NASA's space research agenda, we can aggressively seek and conduct research directly aimed at enhancing commercial space endeavors.

NASA recently established the NASA Advisory Council Task Force for the Commercial Use of Space, chaired by Dr. Thomas A. Vanderslice. Comprised of successful executives representing non-aerospace companies, the "Vanderslice Committee" is taking a very close look at the possibilities for non-aerospace industry participation in NASA-sponsored research. The use of advisory panels, particularly those with an emphasis on non-aerospace participation, will have a significant input in setting NASA's research agenda.

In FY 1986, NASA will conduct research with potential commercial applications in the following technology areas: low-g solidification of superalloys, low density material production, biotechnology, microgravity research, and communications.

Increasing the Availability of NASA Facilities:

Perhaps the greatest barrier to undertaking a commercial space venture is the large capital costs associated with doing the basic and applied research. The greatest "driver" of these capital costs is the use and acquisition of facilities and equipment. NASA is seeking to enable industry and university researchers to consider space flight experimentation without major investments in highly specialized equipment by making available Government facilities and equipment in the same manner that the NASA aeronautics facilities are available to industry.

In FY 1986, NASA has also requested funding to expand the availability of facilities such as furnaces, optical fiber production devices, and automated protein crystal growth devices. These facilities will be made more readily available to researchers examining commercial space technologies.

Stimulate Private Sector Commercial Research:

NASA can help stimulate potential private sector commercial space research through a combination of government funding and private resources. With a focus on the non-aerospace community, this initiative will stimulate entrepreneurial and university involvement in commercial space research, while increasing the number of scientists and engineers involved in these research activities.

Specific mechanisms that will be used to encourage private sector research may include commercial grants to universities and announcements of opportunity for innovative commercial space endeavors. Each of these mechanisms is directed at stimulating private investment by reducing the up-front risks and costs of basic research.

As with any other commercial space proposal NASA receives from the private sector, two key evaluative criteria will be applied: the degree of risk being assumed by the private sector, and the potential benefits that will accrue to the space program and the nation. NASA's role in evaluating these proposals is not to determine "winner" or "loser" commercial space ventures, but rather to stimulate private sector involvement in commercial space endeavors.

Outreach:

Over the last 25 years, NASA has developed a unique infrastructure and working relationship with the aerospace community. In an effort to forge a similar relationship between NASA and companies outside the aerospace community, an outreach program will be conducted to establish a dialogue with universities and those aerospace and non-aerospace companies most likely to pursue commercial space ventures. In addition to establishing a dialogue, this activity will enhance NASA's links with industry, universities, and the financial and insurance communities.

Some examples of outreach initiatives that will be funded in FY 1986 include researcher exchange programs with industry and universities, technical liaison with major industrial sectors, finance and insurance community seminars, and technical information dissemination.

The outreach program will cut across both the Commercial Development and Technology Utilization functions within the Office of Commercial Programs. As important as it is to reach out to universities and aerospace and non-aerospace companies to stimulate commercial space research, it is equally important to establish a dialogue with those companies who may become interested in marketplace applications of existing NASA-developed technology.

Technology Utilization Program:

In FY 1986, NASA's Technology Utilization Program funding request is $11.1 million.

The Technology Utilization (T.U.) program, with its focus on dissemination and application of technology derived from NASA research, will assume a vital role in assuring the synergism needed to encourage the commercial use of space.

The Technology Utilization Program is designed to stimulate widescale transfer and secondary use of aerospace-derived technologies throughout the nation's economy. We believe that the many beneficial uses resulting from NASA's technology transfer efforts in the past have been significant and fully justify the continued emphasis which the Congress and NASA has placed on this important activity.

Over the past two years, NASA has been moving steadily forward in improving its dissemination systems. As reported to this committee last year, system improvements in support of NASA's Industrial Applications Center network, including remote interactive search systems, high-speed computer search capabilities, and expanded use of electronic mail as a delivery mechanism, are continuing to be enhanced. Through our FY 1986 budget request, NASA will strengthen technology transfer and dissemination methods employed by the NASA Industrial Applications Centers.

NASA dissemination center network outreach initiatives are also being strengthened by developing productive relationships with state governments and state-operated institutions serving the technological and economic needs of their industries. These efforts are fully consistent with report recommendations made to the President's Commission on Industrial Competitiveness.

We reported last year on our efforts to commercialize NASA Tech Briefs. A private publisher, the Associated Business Publications, Inc., (ADP) was competitively selected to produce and publish NASA Tech Briefs at no cost to the Government. Under the NASA-ABP Memorandum of Agreement, the publisher will provide, at their own expense, for publication design, printing, distribution, marketing and promotion, and will be allowed to recoup that investment through paid advertising. The commercialization of NASA Tech Briefs will thus allow for continued free distribution of the publication to 75,000 industrial scientists, engineers and business executives nationwide to stimulate commercial use of technologies announced in the periodical.

Moreover, it is expected that the circulation will grow substantially in the future, thus enabling NASA technology to reach an even broader range of industrial users than was previously possible.

During the past year, the T.U. Applications Engineering Program has made significant strides in its effort to modify and adapt or re-engineer existing aerospace technologies to match significant technological problems of national scope. During FY 1984, nearly $6 million in non-NASA support from industry and other Government agencies aided in these jointly-sponsored programs. It is anticipated that during FY 1985, this support may reach the $15 million level.

Among the 22 projects initiated this past year was the development of a crash avoidance radar system for automobiles. This joint project with the Department of Transportation is based on small, lightweight, highly reliable sensors for extravehicular activity developed at the Johnson Space Center. In another project, a cooperative agreement has been finalized between NASA, the U.S. Army and Texas Instruments to develop an improved robotic vision system for industrial automation.

A significant milestone has been reached this year in that NASA, the Administration on Aging, the National Institute on Aging, the National Institute on Handicapped Research, and the Veterans Administration, have collaborated in developing an Interagency Agreement to address several problems facing the elderly. Technology solutions will be sought to well-defined and understood problems. Industry partnerships will be developed to transfer the technology, build and evaluate prototypes, and eventually market new items to assist the elderly. "Spinoff" items may include mobility and communication products.

Joint Endeavor Agreements:

The focus of NASA's efforts to encourage the commercial use of space is on new high technology ventures that create new technology, and new economic activity. One of the key NASA barometers of private sector interest in these new high technology ventures is the number of existing and proposed agreements submitted by private companies. Mechanisms such as Joint Endeavor Agreements have been used by NASA as a way to facilitate the demonstration of commercial applications in space technology through a NASA-industry partnership. Under a Joint Endeavor Agreement there is no exchange of funds between NASA and the private sector. Rather, a "quid pro quo" is established whereby in exchange for a flight or flights aboard the Space Shuttle and/or other services, the private company will structure the experiment, build hardware, package the experiment, and furnish NASA with flight data.

Concern has been expressed in the past about the amount of time it takes a company to negotiate a commercial agreement with NASA. We in the Office of Commercial Programs are sensitive to this concern and have taken steps to streamline the Joint Endeavor Agreement negotiation process. In addition to the Office of Commercial Programs being established as an Agency-wide focal point for the commercial use of space, NASA Field Centers have also established points of contact to expedite review and maintenance of commercial agreements. Every step will be taken by NASA to avoid stifling private sector innovation and creativity by an overly cumbersome approach to proposal evaluations. Recent experience does suggest that when NASA and a private company work cooperatively to establish a commercial space agreement, the NASA system is indeed very responsive. The 3M Corporation and NASA entered into a Memorandum of Agreement covering a joint space-based materials research program in February, 1984. 3M's Diffusive Mixing of Organic Solutions experiment flew on Shuttle Mission 51-A, less than nine months after the original agreement was signed.

The establishment of the Commercial Programs Office and the issuance of the NASA Commercial Use of Space Policy have served to greatly increase the interest level of private companies in pursuing commercial space ventures. We anticipate that NASA will enter into over a dozen new commercial agreements in the current Fiscal Year.

Other Commercial Programs:

It should be noted that the Technology Utilization function represents only one ongoing NASA program that can help stimulate private sector involvement in commercial space activities. For the next few minutes, I would like to briefly describe some ongoing NASA activities and mechanisms that are also contributing to the goal of expanding the level of private investment in space.

For example, the Small Business Innovation Research (SBIR) Program represents an ongoing NASA program that can be particularly useful in increasing the number of companies pursuing commercial space ventures. Using the procedures and practices of the SBIR Program, the Office of Commercial Programs hopes to stimulate the involvement of small businesses in space research activities.

In both FY 1985 and FY 1986, NASA will be taking steps to include small businesses in its efforts to pursue commercial space research. Potential research areas for small business involvement include: electronic materials, metallic alloys, glasses and ceramics, biological materials, fluid dynamics, chemistry and physics, life sciences and space technology.

NASA has also been proceeding with the necessary steps to transfer operation of the Delta, Atlas/Centaur, and Scout expendable launch vehicles (ELV's) to the private sector in accordance with National policy and the recently enacted "Commercial Space Launch Act." The Office of Commercial Programs will serve as the NASA focal point for providing support to the Department of Transportation in carrying out its lead agency responsibilities, and for commercal ventures associated with elements of the Space Transportation System.

A formal agreement between NASA and Transpace Carriers Incorporated (TCI) for the transfer of marketing and production responsibilities for the Delta launch vehicle was signed last year and subsequently three sixty-day extensions of the agreement have been granted. Negotiations with General Dynamics, who has expressed interest in becoming the commercial operator of the Atlas/Centaur Program, are still in process. Inquiries have also been received for the Scout vehicle, but the selection process for a private sector operator has not been completed.

There are currently two existing agreements between NASA and private firms for development of commercial upper stages: one with McDonnell Douglas for the Payload Assist Module (PAM) and one with Orbital Sciences Corporation for the Transfer Orbit Stage (TOS). Several other private companies have made investments in other upper stages, although no agreements with NASA exist at this time. Although some of these upper stage ventures can utilize ELV's, others cannot and therefore their commercial success is highly dependent on the Space Shuttle. Even those that can fly on ELV's have the majority of their investment in support equipment which is Shuttle-unique.

There are two other major agreements which NASA has entered into with private firms for the provision of space flight hardware and services. The first is a Joint Endeavor Agreement with Fairchild Space Company for Leasecraft and a Memorandum of Understanding with Astrotech International Corporation for payload processing services.

Relationships with Other NASA Offices:

The success of NASA's efforts to stimulate commercial involvement in space activities is critically dependent on the quality of the working relationship between the Office of Commercial Programs and NASA's other program offices. A close working relationship has been established with each program office to avoid duplication of effort and to insure the smooth integration of activities. For example, many of the commercial research activities being proposed require on-orbit time in zero-gravity; therefore, the Office of Commercial Programs must work closely with NASA's Office of Space Science and Applications, and the Office of Space Flight (Customer Services Divisions) to achieve the desired results.

For example, our office and the Space Station Office are both new offices which share the goal of developing a permanently manned Space Station that both stimulates and supports commercial endeavors in space. Our relationship with the Space Station Office is a positive one. We have worked with their Utilization and Requirements Division to supply the Space Station mission data base with over thirty new commercially oriented candidate missions. This data base forms the basis of the performance envelope that shapes the Space Station system requirements and includes, as one of three categories, commercial missions. We will also work with the Space Station Office's Policy Group to develop a strategy for encouraging the participation of the private sector in the commercial development of Space Station elements. Such participation in the development phase of the Space Station endeavor could enhance significantly the Station's capabilities when they become available early in the 1990's. The Space Station program places a heavy emphasis on mission or payload requirements and we can be assured, I believe, of the program having a strong commercial dimension.

Key Challenges in Encouraging the Commercial Use of Space:

The Office of Commercial Programs stands ready to assist aerospace and non-aerospace companies in their pursuit of commercial space endeavors. Some of the major challenges NASA will face in carrying out this mission involve developing an adequate microgravity research data base, reaching out to the non-aerospace entrepreneurs, and assuring affordable access to the Space Shuttle.

Mr. Chairman, the support of this Committee in focusing on commercial space issues has been appreciated and we look forward to building on this established relationship in the future.

Responses to Written Questions from Chairman Nelson.

Question I-1:

The Office of Commercial Programs is aligned in 3 divisions: commercial development, plans and policy and technology utilization. Can you describe the functions of each division.

Answer I-1:

The function of the Commercial Development Division is to manage the implementation of those initiatives that will help to expand the level of private sector investment in space. Specific examples of commercial space initiatives being managed by the Commercial Development Division include:

- Centers for the Commercial Development of Space
- Stimulating NASA Research with Commercial Potential
- Stimulating Private Sector Research with Commercial Potential
- Increasing the Availability of NASA Facilities and Equipment.

The Commercial Development Division is also responsible for the coordination and maintenance of proposed and existing commercial space agreements.

The function of the Technology Utilization Division is to stimulate the widescale transfer and secondary use of aerospace-derived technologies throughout the nation's economy. The Technology Utilization Program, with its focus on dissemination and application of technology derived from NASA research, will assume a vital role in assuring the synergism needed to encourge the commercial use of space.

The function of the Plans, Policy and Evaluation Division is to review NASA policies as they relate to encouraging the commercial use of space, and support other divisions of the Commercial Programs Office in this regard. This division is also responsible for inter-organization liaison, industry outreach, and further efforts to encourage the commercial use of space.

Question I-2:

What is the current and projected size of your staff at the Office of Commercial Programs?

Answer I-2:

There are currently 30 NASA employees assigned on a full-time permanent basis to the Office of Commercial Programs. The full-time equivalent (FTE) size of the Commercial Programs staff will be approximately 35-40.

Question I-3:

How will your office coordinate with other NASA program offices?

Answer I-3:

The success of NASA's efforts to stimulate commercial involvement in space activities is critically dependent on the quality of the working relationship between the Office of Commercial Programs and NASA's other program offices. A close working relationship has been established with each program office to avoid duplication of effort and to assure the smooth integration of commercial space activities. For example, as many of the commercial research activities being proposed require on-orbit time in zero gravity, a close working relationship has been established with the Office of Space Science and Applications and the Office of Space Flight.

Similarly, the Office of Commercial Programs and the Space Station Office are both new office which share the goal of developing a permanently manned Space Station that both stimulates and supports commercial endeavors in space.

Specifically, the Commercial Use of Space FY1985 and FY1986 programs have been developed with the advice and consultation of both the line and staff offices at NASA Headquarters through coordinating committees and joint agreements. The Office of Commercial Programs intends to continue, and indeed, strengthen this coordination process.

Question I-4:

The budget request of $30 million for this office is nearly 400% over last year's reprogramming action for the program of $8.5 million.

-- Do you feel that the program is mature enough that it can realistically spend $30 million in FY1986?

-- How does this funding level relate to projections for a commercial market for space products?

-- What do you currently estimate will be your level of spending in the next 3-5 years?

Answer I-4:

Based on the broad range of commercial space research proposals generated by NASA field centers, as well as the general level of interest of private companies in commercial space endeavors, NASA believes the Commercial Program function will be in a position to responsibly allocate $30 million in FY1986. A significant portion of this funding will support NASA's Centers for the Commercial Development of Space. As with other Commercial Program initiatives, NASA funding of these Centers will be contingent on a significant contribution of industry resources to a commercially viable research endeavor.

NASA's efforts to stimulate private investment in space are directed at technology efforts which hold the greatest economic promise. The greatest growth potential of commercial space endeavors is in the microgravity research sector. This market sector shows the potential for great strides in fostering economic growth and competiveness, and enhancing life on earth.

The FY1986 funding request of NASA's Office of Commercial Programs ($30 million) will build upon the commercial use of space activities initiated in FY1985. Estimates of NASA's spending level in this area during the next three to five years will be based on initiatives funded in FY1986.

Question: I-5:

A guiding philosophy of the NASA Office of Commercial Programs is that funds will not be committed until substantial industry interest and commitment have been obtained for any particular initiative.

-- Can you elaborate on how this principle will work, and how it will affect the activities of your office?

-- In the few short months that your office has existed, has substantial industry interst been shown?

-- Of the $8.5 million funds reprogrammed to support the activities of your office for FY1985, how much of it represents initiatives that have been committed to by industry, and what are they?

-- Are you optimistic about industry commitment to the $30 million?

Answer I-5:

NASA requires demonstrated industry interest in a commercial space project prior to the commitment of funding. This interest may be any tangible resources such as capital, hardware, services, manpower, etc. As such, a primary criteria used by NASA to evaluate proposed research endeavors will involve the extent to which industry is commited to moving a commercial space technology from the laboratory to the marketplace.

The establishment of the Office of Commercial Programs and the issuance of NASA's Commercial Use of Space policy has undoubtedly increased industry interest in commercial space. Significant interest exists in materials processing and the manufacture of space hardware.

The Office of Commercial Programs is currently in the process of gathering industry commitments to FY1985 commercial space initiatives. While at this point no specific dollar figure can be attached to industry commitments, NASA field centers are in the process of securing industry commitments of any resources to fund initiatives contained in the FY1985 Commercial Programs budget.

NASA remains optimistic about the willingness of industry to share the costs of commercial space endeavors which evolve from NASA Commercial Programs funding.

Question I-6:

What are your major initiatives for FY1986? will your primary emphasis be on R&D processes or commercial products? Where should it be.

Answer I-6:

The FY1986 funding request of NASA's Office of Commercial Programs will build upon the commercial use of space activities initiated in FY1985. In seeking a greater private sector commitment of resources to commercial space research and development, NASA's FY1986 commercial programs budget request will support the commercial development of space in the following areas:

- Centers for the Commercial Development of Space
- Stimulating NASA Research with Commercial Potential
- Stimulating Private Research with Commercial Potential
- Increasing the Availability of NASA Facilities and Equipment

In addition, NASA's FY1986 funding request for the Technology Utilization Program ($11.1 million) will help to stimulate the widescale transfer and secondary use of aerospace-derived technologies throughout the nation's economy. The Technology Utilization Program will assume a vital role in assuring the synergism needed to encourage the commercial use of space.

As such, NASA efforts to encourage the commercial use of space are directed at helping to establish the research and development foundation for industry funded commercial product development.

Question I-7:

How much of your budget will actually go toward the support of R&D? Will your office be in a position to supplement the research budgets of other NASA programs.

Answer I-7:

NASA's FT1986 Commercial Programs budget has been developed to encourage the commercial use of space in two broad areas: Commercial Development and Technology Utilization. All of the proposed FY1986 funding for Commercial Development ($30 million) and Technology Utilization ($11.1) will be directed at Research and Development and related activites. These research activities will be directed at research which industry feels will have the greatest potential for establishing the foundation for commercial space ventures.

Based on a tangible commitment of industry resources to fund a proposed commercial space endeavor, the Commercial Programs office may consider funding research projects thatwould supplement the research budgets of other NASA programs.

Question I-8:

I see about a third of your budget will go toward increasing the availability of NASA facilities and equipment to the private sector

-- Can you elaborate on this? What do these funds represent?

-- Would these funds otherwise be in the construction of facilities budget

-- The primary objective of NASA's Office of Commercial Programs is to expand the level of private sector investment in space related activities. Based on your experience, how would you describe private sector investments made to date in commercial space ventures.

Answer I-8:

Commercial Programs funding in the "Facilities and Equipment" area will support activities that will enhance NASA's capabilities to support terrestrial and space-based research with potential commercial space applications. No "brick and mortar" funding is contained in the "Facilities and Equipment" initiative. Developing space facilities and equipment, as well as assuring better industry access to existing facilities and equipment will aid in the development of the research and development foundation that will support commercial space endeavors.

As expanding the availabilty of these NASA facilities and equipment will stimulate commercial space research and development, funding in this area would not otherwise be in NASA's Construction of Facilities budget.

Private investments in commercial space ventures have been made in launch services, on-orbit services, remote sensing, advanced communications, and materials processing. NASA has not as yet made an attempt to estimate the level of investment made by the private sector in pursuing space-based commercial ventures. The Orbital Sciences Corporation (OSC) has made such an estimate, however, and it shows that approximately $260 million has been invested in Shuttle-based commercial space endeavors, and $24.5 million in ELV-based commercial space ventures.

Question I-9:

What kind of outreach program are you planning?

-- What will the role of the centers be in this outreach

-- How will the outreach effort be undertaken

Answer I-9:

A key objective of the Commercial Outreach program is to create the institutional mechanisms that will help stimulate a strong partnership between business, universities, and NASA. Such an Outreach program will help to communicate the steps NASA is taking to reduce the technical, financial, and institutional risks of doing business in space.

As the bulk of NASA's research and development activities that will stimulate the commercial use of space will be carried out by NASA field centers, field center involvement in the outreach program will be essential. NASA field centers will serve as the principle conduit of the Outreach program.

NASA is currently examiming alternative outreach mechanisms. Examples of outreach initiatives for which funding is proposed in FY1986 include researcher exchange programs with industry and universities, technical liaison with major industrial sectors, finance and insurance community seminars, and technical information dissemination.

Question I-10:

NASA plans to create centers for the commercial development of space to conduct research to develop space-based processes with potential commercial applications. Plans include funding 3-6 centers at a rate of $500,000 to $1 million each.

-- What is the current status of this initiative?

-- Where will the centers be located

-- Will NASA, or industry, decide the particular applications focus at each center?

-- NASA anticipates the centers will be self-sustaining, after several years, with funding from the private sector. What incentive would a company have to join with other companies and NASA in this kind of arrangement, as opposed to setting up its own in-house "science center?

-- How does these centers compare to "Centers of Excellence" funded by NASA.

-- How does NASA go about protecting the proprietary data that results from a commercial agreement with industry? What intellectual property rights protections will be made available to participants in centers for the commercial development of space?

Answer I-10:

NASA recently invited industry, universities, and others to respond to a Center for the Commercial Development of Space Notice of Opportunity. Based on our current plans, we expect to receive these proposals by June 1985, and award funding by early September 1985. A review panel comprised of representatives from industry, universities, and government agencies will evaluate the technical and business merits of these proposals.

NASA will be unable to determine the location of these Centers until proposals are submitted and evaluated by a review panel. Geographical distribution of federal funds will be a consideration in the selection process.

The teams of industry, university, and non-for profit respondents to NASA's Centers for the Commercial Development of Space Notice of Opportunity will determine the research focus of each center.

The primary incentive to participate in the Center for the Commercial Development of Space program lies in the costs of doing basic research. As the type of research that will be conducted by the Centers is usually fairly expensive, a company would need a very large research budget to acquire such a broad range of data. Industrial participation in this program represents a cost-effective approach to the basic research that can provide the foundation for private sector application and development of commercial space technologies.

The difference between these efforts is one of focus. Centers for the Commercial Development of Space will focus on research aimed at processes with commercial potential, with the goal of increasing our general knowledge and understanding of basic science becoming a secondary objective. Industry will have a significant input in setting the research agenda of the Centers for the Commercial Development of Space. This focus is reversed with the Centers of Excellence in the Space Science and Applications program.

Under the terms of a Joint Endeavor Agreement, each party carries out stated responsibilities on its own behalf. Agreement on the treatment of rights to inventions and patents must be stated in the Joint Endeavor Agreement. As the objective of a commercial agreement with NASA is to demonstrate the usefulness of space technology to meet marketplace needs, the commercial participant may retain all right, title and interest to any inventions and resulting patents, with NASA retaining certain contingent rights consistent with that objective.

Data rights associated with the Centers for the Commercial Development of Space will be subject of individual negotiation and will be set forth in an appropriate clause consistent with the following:

- o Some data of a general nature are to be furnished to NASA without restriction (i.e. with unlimited rights).
- o The awardee may retain rights in potentially commercially valuable data produced in the performance of the agreement for an agreed period, during which delivery to the Government, if any will be under protective conditions regarding disclosure and use of the data.
- o In no event will data developed at private expense, including compute software, that embodies trade secrets or is commercial, financial, or privledged be required to be delivered.

Question I-11:

The National Commercial Use of Space Policy plan outlines initiatives to reduce the technical, financial, and institutional risks of doing business in space.

- What is the current status of implementation of this plan?
- Has your office identified initiatives for priority attention? If so, how have priorities been identified?
- One area that could be utilized to stimulate commercialization is the procurement area. for example, during the course of a competitive procurement, additional credit could be given to systems which have been developed with private financing.
- What is NASA doing in this area, and to allow new companies to compete equitably with other government contractors?
- One of the key procedural initiatives contained in NASA's commercial use of space policy involves streamlining the Joint Endeavor Agreement negotiation process. What steps has NASA taken to streamline this process?

Answer I-11:

The implementation of the National Commercial Space Policy is currently under consideration by the Cabinet Council on Commerce and Trade Commercial Space Working Group. A NASA representative serves as Vice-Chairman of that Working Group.

As the Research and Development Initiatives contained in the National Commercial Space policy directs the United States Government to expand basic research and development with commercial space applications, NASA will give priority attention to research and development activities which will stimulate the commercial use of space. NASA's efforts to encourage the commercial use of space are grounded in the agency's research and development mission.

Existing procurement statutes do not provide for giving preferential treatment to a class of offerors during the course of a competitive procurement. Selection criteria, in our judgment, must be chosen carefully enough to apply equally to all offerors and support free and open competition in regard to the technical necessities of the requirement. NASA will use the government procurement process within the criteria established above, and other relevant existing criteria, to encourage the commercial use of space.

The Office of Commercial Programs is sensitive to private sector concerns about the amount of time it takes to negotiate a commercial agreement with NASA. Every step will be taken by NASA to avoid stifling private sector innovation and creativity by an overly cumbersome approach to proposal evaluations. In addition to the Office of Commercial Programs being established as an Agency-wide focal point for companies pursuing commercial space endeavors, NASA field centers have also established points of contact to expedite review and maintenance of commercial space agreements.

Question I-12:

What is your office doing to shape the role of the private sector on space station activities? Are efforts underway to ascertain the ability and willingness of the private sector to fund privately, development of space station components and subsystems?

Answer I-12:

The Office of Commercial Programs and the Space Station Office are both new offices which share the goal of developing a permanently manned Space Station that both stimulates and supports commercial space endeavors. Our relationship with the Space Station Office is a positive one. We have worked with the Station utilization and Requirements Division to supply the Space Station mission data base with over thirty new commercially oriented candidate missions. This data base forms the basis of the performance envelope that will shape Space Station missions.

A representative of the Office of Commercial Programs currently serves as a representative on the Space Station Commercial Advocacy Group. The Commercial Programs Office will also work with the Space Station Office's Policy Group to develop a strategy for encouraging the participation of the private sector in the commercial development of Space Station elements. Such participation in the development phase of the Space Station will enhance the Station's capabilities to support commercial mission.

Efforts are currently underway to evaluate private sector interest and capability to privately fund development of space station components and subsystems.

Question 1-13:

What, in your view, is the long range scenario for space commercialization for say the next 5-10 years?

-- What do you think NASA will be doing in the next 5-10 years in this area?

-- When do you think we can expect a commercial company to be producing a commercial product in space and making a profit?

-- Has your office identified long range objectives for commercial use of space to guide your activities?

Answer I-13:

NASA will be taking a long-term approach to encouraging the commercial use of space. Commercial space ventures are characterized by long-term payback outlooks. During the next five to ten years, NASA hopes to stimulate the basic research that can provide the foundation for commercial developments in space in the coming decades. The Space Shuttle and evenutal Space Station capabilities will be integral to NASA's efforts to expand the level of private sector investment in space.

An example of how the long-lead times associated with commercial space ventures result in long-term payback outlooks is the McDonnell Douglas/Johnson & Johnson development of the Continuous Flow Electrophoresis System (CFES). The McDonnell Douglas Corporation began work on the Electrophoresis Operations in Space project in 1977. While this device has flown on five shuttle flights to test its operational characteristics and verify the advantages of processing in space, the company estimates it will be another three to five years until a marketable product is developed.

An agency goal of the National Aeronautics and Space Administration is to expand the level of private sector investment in space and space-related activities. In support of this goal, a long-term objective of the Office of Commercial Programs is to help establish the research and development foundation for industry funded commercial product development.
Additional long-term objectives are in the process of being identified.

Question I-14:

This Subcommittee recently held hearings on Shuttle pricing policy. As the manager of NASA's program to encourage private investment in space, how do you interpret the view of those who suggest that increasing the price of Shuttle launch services will foster the growth of a U.S. commercial expendable launch vehicle industry?

Answer I-14:

Consistent with Administration policy, NASA supports the privatization of expendable launch vehicles. The international competition in the launch services market is dominated by the Space Shuttle and Ariane. Significant increases in Shuttle launch costs beyond Fiscal Year 1988 may foster the growth of a U.S. commercial expendable launch vehicle industry.

Question I-15:

What has been the role of the commercial programs office in evaluating private sector proposals to purchase or lease a Shuttle orbiter? What is the status of these negotiations?

Answer I-15:

The Office of Commercial Programs has lead agency responsbility, in conjunction with the Office of Space flight, for negotiations involving private sector proposals to purchase or lease a shuttle orbiter.

NASA's discussions with Astrotech have never been raised to the negotiation level. Astrotech is currently developing another concept for NASA's consideration.

Question I-16:

Has the establishment of the commercial programs office and the issuance of the NASA commercial use of space policy served to increase the number of companies pursuing commercial space ventures?

Answer I-16:

The establishment of the Office of Commercial Programs and the issuance of the NASA Commercial Use of Space policy has undoubtedly served to increase the interest level of aerospace and non-aerospace companies in commercial space ventures. These actions have increased the number of companies pursuing space ventures insofar as NASA has recently established several new commercial agreements with private companies, and that the Office of Commercial Programs expects to establish over a dozen new commercial agreements in the coming fiscal year,

QUESTION I-17:

The $11.1 million for technology utilization for FY86 anticipates spending at headquarters at a level of $5.7 million.

-- Why so much at headquarters?

-- What are the centers doing, and why isn't more being spent at the centers?

-- Most center funding in this area has remained level over the last 2 years, except for Ames, which jumped almost $2 million. What initiative does this reflect?

ANSWER I-17:

a) Traditionally, NASA has operated its technology dissemination component of the TU Program on a centralized basis. The $5.7 million at Headquarters in FY86 constitutes R&D contract support to operate the NASA dissemination center network, including Industrial Applications Centers, State Technology Applications centers, and COSMIC, located at the University of Georgia. In addition, the Headquarters funding includes new technology evaluation at SRI International as well as publication preparation contracts to prepare material for dissemination. All NASA Field Centers use these centralized contractor capabilities to carry out their respective functional activities in new technology evaluation, publication preparation and technology dissemination, but they are funded out of Headquarters.

b) In addition to their support to new technology identification, evaluation, publication functions under technology dissemination, NASA Field Centers are responsible for managing applications engineering projects under the technology applications component of the TU Program. Thus, the majority of TU appropriated funds in this area are spent at the centers to support specific application projects based on each center's technical capability and expertise. The FY86 budget request shows a significant increase in the technology applications component, thus more funds are to be spent by the NASA centers in FY86 compared to previous years.

c) The purpose of the ARC increase is to support technology transfer to the U.S. helicopter industry.

A great deal of new helicopter technology has been developed by NASA, much of which is ready to be applied to new helicopter design. Also, trauma experts have frequently expressed a need for a helicopter designed to meet the medical evacuation requirement. If these new technologies were applied to the development of a public service helicopter, these aircraft could become an integral part of a trauma care system that could reduce the estimated 115,000 annual trauma deaths by half. In addition, the increased distance and transit times of these helicopters could significantly increase the level of emergency medical care in rural areas, police protection and search and rescue missions. NASA and the helicopter industry are now cooperating in a Phase A study to:

- Understand advancing helicopter technology
- Define the user requirements
- Assess the market potential
- Define elements requiring technology improvement
- Identify applicable new technology
- Prepare a plan of future recommendations and actions needed

NASA technologies being studied are precision guidance, navigation and control technology, noise and vibration reduction and designs for all-weather capability.

QUESTION I-18:

What is NASA doing to ensure the dissemination of technology to the public sector, and particularly the nonaerospace segments of the economy?

ANSWER I-18:

Aerospace technology is aggressively disseminated and transferred to U.S. industry and the public sector in a variety of ways through the NASA Technology Utilization Program. These include:

Publications - Announcements of new and innovative technologies arising from NASA research and development programs having potential uses and applications throughout both public and private sectors of the economy.

Industrial Dissemination Network - A nationwide network of university-based centers where existing aerospace technical, scientific and management information and expertise is applied to identified problems in U.S. industry and state and local governments.

Computer Software Dissemination - A specialized center is sponsored by NASA to provide aerospace-derived computer programs to industry and other government agencies for secondary use.

Application Teams - Multidisciplinary groups of technologists to assist public sector organizations in applying aerospace technologies to defined needs.

Applications Engineering Projects - Joint projects to adapt or "re-engineer" existing NASA technology to meet specified needs of other Federal agencies.

These and other less formal transfer mechanisms, such as conferences and seminars for industry, are the major NASA efforts to disseminate and transfer its technologies in creative and useful ways to U.S. industry.

QUESTION I-19:

Among the various technology applications projects described in last year's TU testimony was the Programmable Implantable Medication System (PIMS) which reportedly may have long range beneficial consequences in the treatment of certain chronic and debilitating diseases.

Has FDA now approved the application of PIMS for human implant? If so, has the device been implanted? With what results?

ANSWER I-19:

The FDA approved the device for human implant. We are now in the process of satisfying the Johns Hopkins Medical Institute's Joint Committee on Clinical Investigations (JCCI) requirements for human implant.

As of this date, the PIMS has not been implanted in a human. The reason for holding back on the first implant is technical. Just prior to initiating the first implant, a diaphragm in one of the test models fatigued, causing a major systems failure. Upon further investigation, it was found that this represented a major design flaw. Attempts to modify the design were proven unsuccessful and a change was made to use a bellows system in leiu of the diaphragm. Prior to implanting the newly designed system into a human, the bellows system is going through animal trials; these trials will satisfy the JCCI requirements. The bellows system is working so well that we feel the first human implant will take place in late spring.

QUESTION I-20:

In last year's budget testimony on Technology Utilization, various operational enhancements of the NASA Industrial Applications Center network, and the expansion of the network to build outreach relationships with other state programs for economic and industrial development were mentioned. How are these efforts progressing, and are they leading toward increased technology dissemination services to broader segments of U.S. industry?

ANSWER I-20:

The operational enhancements referred to in last year's testimony include (a) Remote Interactive Search Systems (RISS), (b) computerized pre and post-processing techniques and (c) expanded use of electronic mail for more rapid information product delivery to clients. The RISS capability is now in place and operational at four of the network centers. The pre and post-processing techniques to enhance search capabilities and relevance of search results are still in the development stages and should be available for operational integration some time next year. All centers now possess electronic mail delivery capability and use of these systems is increasing steadily in complying with rapid response requirements of more and more industrial clients. Establishment of such operational enhancements requires relative long term commitments and the rate of progress is largely dependent on available resources for equipment upgrade as well as the preceived needs of the industrial clients.

Outreach relationships with other states over the past year have been built within Iowa, Colorado and Washington (through the IAC at the University of Southern California); Pennsylvania and Delaware (through the IAC at the University of Pittsburgh); and in Alabama, Tennessee and Georgia (through the Florida State Technology Applications Center, University of Florida). Additional discussions are underway with institutions in the following states: Idaho, Arizona, Utah, Hawaii, Maryland, West Virginia, Virginia, South Carolina, Mississippi, Arkansas and Louisiana. As a result of cooperative agreements with the states in question, the IACs will enable state institutions to provide technology services, through the IACs, to their own constituencies at costs which are far less than would be required should the states undertake to establish independent centers on their own. Though it is too soon for the economic and industrial development agencies within the individual states to measure the effects of these cooperative arrangements, positive results are uniformly anticipated.

QUESTION I-21:

The President's FY86 budget calls for the elimination of the Small Business Administration. If this should occur, what impact would the dissolution of the SBA-sponsored Small Business Development Centers have on NASA's efforts to provide technology dissemination and transfer services to small business firms?

ANSWER I-21:

P.L. 96-302 required that NASA and SBA cooperate in developing close working relationships between NASA Industrial Applications Centers and the Small Business Development Centers. Over the last several years, increased cooperation between these groups has substantially increased. The SBDCs have provided NASA IACs with a broader outreach capability to provide technology dissemination and transfer services to small businesses and small manufacturing firms. Interactive relationships have now been established with more than one-half of the 32 existing SBDCs across the nation. The dissolution of the SBDC program would require NASA Industrial Applications Centers to strengthen and materially increase their ability to reach small businesses currently being served by the SBDCs resulting in increased funding requirements for the NASA IACs.

QUESTION I-22:

NASA is commercializing Tech Briefs, a principal technology transfer and announcement mechanism.

-- What is the Tech Brief journal?

-- What does its commercialization mean for NASA?

ANSWER I-22:

The NASA Tech Briefs is a quarterly periodical which announces 120-140 new technical and scientific advances that may have potential utility in U.S. industry. The publication is disseminated to over 75,000 industrial scientists, engineers and businessmen in U.S. companies nationwide to promote or otherwise encourage the adoption, application and use of these new technologies in industry.

The commercialization of NASA Tech Briefs will allow a distribution of the Tech Briefs to a wider audience, but at a decrease in the total cost to the U.S. government, thereby furthering the NASA objectives in technology transfer to industry.

QUESTION I-23:

What is NASA doing to address the needs of small and minority firms?

ANSWER I-23:

Through the Industrial Applications Centers (IACs) and State Technology Applications Centers (STACs), NASA has continued to provide answers to technical questions and otherwise assist small business firms, which constitute approximately 70% of the total IAC/STAC industrial client base. In addition, specific cooperative relationships have been established by a number of IACs and STACs under the Small Business Development Centers (SBDC) and Small Business Innovation Research (SBIR) programs, as seen in the following examples:

- The NASA IAC at the University of Southern California has provided technology search services to SBDC activities in Iowa, Colorado and Washington through a Remote Interactive Search (RIS) system to link terminals between the IAC and the state recipients for efficient and cost-effective requesting and delivery of technical information.
- The STAC at the University of Kentucky has responded to 65 requests from the SBDC at that location, primarily aimed at providing information on the feasibility of utilizing new technologies, procedures or services by startup businesses in the State of Kentucky.
- The IAC at the University of Pittsburgh has worked closely with the SBDC located on-campus and with another located at Duquesne University. The IAC and SBDCs have jointly participated in two conferences which attracted approximately 300 small businesses from northern Pennsylvania. The IAC has also provided specific support to an additional 20 firms by providing technology searches in support of their applications for SBIR grants.
- Activities similar to the above have been undertaken at the IACs located in Indianapolis, Indiana and Durant, Oklahoma, as well as at the STAC at the University of Florida.

Though it is not always possible to determine the degree of minority ownership in firms served by the IACs and STACs, each of these centers endeavor to enlist minority firms among its clients. In the case of the Florida STAC, approximately 40 firms, or 15% of the client total, are minority-owned. A similar situation exists at the IAC at the University of Southern California.

QUESTION I-24:

NASA has worked to realign and improve the technology dissemination system, including centralizing information search capability and modernizing communications media. What progress has been made to reduce tech transfer costs and improve the capability and systems for dissemination?

ANSWER I-24:

Each of the NASA dissemination centers has been encouraged to increase their utilization of microcomputers as a means of conducting database search operations as well as a tool for performing additional necessary functions in spreadsheet and database management operations. An analytical study is currently in progress to determine ways in which resources which are now in place or planned for the near future can be most effectively combined to benefit overall network operations. Though no firm data is yet available, it is believed that utilization of a gateway computer system with which we are now experimenting in conjunction with the Lawrence Livermore National Laboratory will appreciably reduce database searching costs through centralized aggregation of database capabilities. The utilization of a Unix-based electronic mail system over the past year as part of this gateway capability has appreciably improved our ability to operate effectively as a network. The anticipated completion before the end of this year of new software for extracting additional intelligence from electronic databases is expected to further improve our capabilities to make the results of NASA and related research and development available to industry in increasingly useful ways.

QUESTION I-25:

NASA has worked to consolidate the transfer of NASA developed technologies into 3 main areas, automation and electronics, materials and bioengineering and rehabilitation.

a. Are these areas still receiving primary emphasis?

b. Are other areas being explored?

ANSWER I-25:

The primary focus of the Applications Engineering program is a fairly even distribution between automation, electronics, materials, bionengineering and rehabilitation. The program is further divided into feasibility studies, engineering definition studies and prototype development; each addressing some of the five categories above.

Other areas are being explored as the opportunities avail themselves. For instance, the acquatic plant filtration technology developed at the National Space Technology Laboratories is being transferred to state and local governments in California, Florida and Louisiana. Satellite technology used in coastal zone scanning is being studied for possible aircraft adaptation to provide data to U.S. commercial fishing industries; and, helicopter technology is being studied by NASA, industry, other Federal, State and quasi government agencies for application to public service helicopters.

Question I-26:

What role does the small business innovation research program have in stimulating the commercial use of space?

Answer I-26:

The Small Business Innovation Research (SBIR) Program represents an ongoing NASA program that can be particularly useful in increasing the number of companies pursuing commercial space ventures. Using the procedures and practices of the SBIR Program, the Office of Commercial Programs hopes to stimulate the involvement of small businesses in space research activities. In both FY1985 and FY1986, NASA will be taking steps to include small businesses in its efforts to pursue commercial space research. Potential research areas for small business involvement include: electronic materials, metallic alloys, glasses and ceramics, biological materials, fluid dynamics, chemistry and physics, life sciences, and space technology.

Mr. NELSON. OK, thank you for your testimony.

Is there a dollar figure that you can put when Mr. Walker and I get asked continuously, how much of a dollar of a business is space commercialization going to be in 19—the turn of the century?

Mr. GILLAM. The only estimate that I am familiar with is one that has been made by the Center of Space Policy. I do not know the rationale that they used to make that estimate, however, they estimate that the—by the year 2000 commercial activities in space can run into about a $65 billion a year activity.

Mr. NELSON. What are your major initiatives for fiscal year 1986?

Mr. GILLAM. One—the major initiative for 1986 that we are beginning in 1985 is the Centers for Commercial Development. These Centers are not really new conceptually because NASA has Centers of Excellence that have been focusing on science. These centers will be operated in a reasonably similar manner. There will just be a slight difference. Centers of Excellence will be funded by our office will focus on science with commercial potential, rather than science for the general nature of science. So, we will focus on those specific activities that we are given direction on from our advisory committee, from the private sector and from the other sources that we have for information. They will operate in the same manner as the centers of excellence. We would hope to have three to six in operation by fiscal year 1986.

Mr. NELSON. Now, how do they differ from your Industrial Application Center?

Mr. GILLAM. The principal purpose of the Industrial Application Centers is to disseminate information—to take the technology that is on the shelf and make sure that that technology is disseminated to the private sector. The principal focus of our centers for commercial development will be basic research. It will be basic research mostly in the material sciences areas, since that's the area that seems to hold the most promise, but it will also—there will also be opportunities for research in remote sensing and in communications and other areas with commercial potential.

Mr. **Nelson**. OK, I'll follow this up in a minute. Mr. Walker.

Mr. **Walker**. Thank you, Mr. Chairman. The commercial centers that you're talking about and the industrial application centers or industrial development centers that you're talking about, is there going to be some effort made to utilize the assignment of those centers to spread NASA's presence into areas of the country that previously NASA has not worked with? I'm thinking about the fact that NASA necessarily developed, over a period of time, focusing on aerospace activities and that tended to make NASA dominant in particular parts of the country. And it seems to me that here's a great opportunity to make certain that NASA's presence and basically the space program's presence is felt in areas of the country that have not been largely—featured the NASA presence. Is that something that's going to be taken into account?

Mr. **Gillam**. We have not considered that as yet. That is something that we can take into account and we can add—we can give consideration to that in our selection process. I'll have to answer that question for you after we've had an opportunity to take a look at it. I can't give you—we have not thought of it. It does represent a possibility. As you probably know, the micro-gravity program in the Office of Space Sciences awarded two contracts last year for Centers of Excellence, one going to the University of Arizona and Bio-Tech and one going to the Philadelphia University Science Center in Bio-Tech. We do intend to have a peer review process for these areas to make sure that the experts in the field have stated that their research agenda is appropriate, but that's something that may be considered and we'd like to give you an answer after we've had an opportunity to consider it.

Mr. **Walker**. Well, I think we take as an obvious that we're only going to put centers at places that can do the work and that—where the peer review process evaluates them as being capable of doing the work. That's a given. On the other hand it does seem to me that in the Northeast you have tended to have a concentration of industries in the Northeast over a period of time that were basic industry structures that did not adapt very well to the original NASA programs. The Apollo Program and some of those just were not—it was not a program that adapted itself well to heavy steel industry in Pennsylvania or elsewhere. Now, as you begin to reach out to the small business community and you begin to reach out to industrial applications, you begin to assign work aimed at bringing more work into the commercial process, it seems to me that you do have a real opportunity, at that point then, to reach into some of those areas with these centers and it will help a great deal to build support then for the overall mission of NASA in commercializing space activities.

As you have begun to get the office underway, what are you finding that business is telling you are their chief problems in dealing in space?

Mr. **Gillam**. There are a couple. One seems to be quite significant. When you say, "doing business in space," the immediate reaction is that that's very expensive. Second is that——

Mr. **Walker**. And they're right, isn't it?

Mr. **Gillam**. In a way, yes, but maybe not as expensive, in many cases, as they think. The second one is that what we're talking about here is a research program, initially. Out of the research program will come ideas for exploration. The basic thing is that we haven't done our homework. We haven't gotten the research data that we can take to industry and that's the reason that our primary focus right now is on the accomplishment of research, and you will find that most of our budget is on getting that work done so we can carry that data to industry.

Mr. **Walker**. Is it your impression that they would be willing to bear the expense, in many instances, if they understood that there is real profit to be made in their activities in space?

Mr. **Gillam**. My understanding is that when you give them some data that shows certain potential they would be willing to bear the expense of developing or exploiting that capability and that's what we intend to do. Our program is basically a research program to get the data to give industry the idea, so that industry can do what it does best, which is to develop or exploit the potential.

Mr. **Walker**. Well, given that scenario isn't there one other factor though, which of course this subcommittee doesn't have the power to do, but might enter into it also, and that would be to give businesses certain economic incentives for then moving on to—for instance if their concern is cost and then we say we could overcome that with some research, wouldn't it be also a good idea, within our commercial space policy, for instance, to give them major tax breaks. To say that any profits generated from space activity for a 10-year period are tax free. That would certainly overcome some of their reluctance to put forward the up-front money, wouldn't it?

Mr. **Gillam**. That probably would do that, sir, but that not being my area I couldn't comment except to say that what we've been striving for in terms of legislation and other things, is to eliminate those provisions in the law that seem to put space potential industries at a disadvantage and what we've been trying to do is level the playing field, so to speak, through things like the determination of export and those other kinds of things.

Mr. **Walker**. Sure, we have to overcome the regulatory nightmare that they think they face and I think we're moving toward that. We certainly have to assure them that is they bring a product in from space that we're not going to charge them tariffs on it.

Mr. **Gillam**. Right.

Mr. **Walker**. You know, we've got a lot of things of that type, but if I understood your first answer correctly, you know, the major concern that they have right now is—as you go to them is, gee, even if you can show me that there's something worth doing there it's going to cost me an awful lot of money.

Mr. **Gillam**. And it's going to take a good deal of time to get to the product

Mr. **Walker**. And it's going to take a good deal of time. So that if we could find a way of giving them incentive to take the cost risk that would help, is that right?

Mr. **Gillam**. Definitely.

Mr. **Walker**. And if we would find some way of assuring that they can begin that work on a timely basis that would be the other great help that we could provide, is that correct?

Mr. **Gillam**. Correct.

Mr. **Walker**. And I assume then that the research that you're doing is going to be aimed at speaking to those issues. I mean how do we—how do we make it less costly for businesses to do business there.

Mr. **Gillam**. Definitely.

Mr. **Walker**. And how to we provide them the kind of timeliness that assures that they don't have a 25 year lead-time.

Mr. **Gillam**. Correct.

Mr. **Walker**. Thank you, Mr. Chairman.

Mr. **Nelson**. Ms. Meyers.

Ms. **Meyers**. In your testimony you alluded to three to six centers for the commercial development of space at a rate of $½ million to $1 million per center, per year, beginning in fiscal year 1985. Where will those be and will they be at universities? Tell me a little bit about those.

Mr. **Gillam**. We are going out with a competitive process to select the centers. We expect to have a request for proposals hit the street about March 8. The location of these centers, we expect to have the proposals vary. Some may be located in industrial laboratories. Some may be located in universities. We had a conference—a sort of bidder's conference around the December 19 last year and sent out notices to interested parties, so that they could come in and comment on our request for proposals. We had about—the response was about 200 people attended representing the university community, State and local governments, and the private sector. So, a great deal of interest has been displayed in these centers and the locations will be determined as a result of the competition. We do not have any preference in mind, in other words there will be two at a university and one at an industrial lab. The best proposers, be they all at universities or all at industrial labs, will win the initial round of competition.

We would expect to start three of these centers each year. Three or four new ones each year, depending on the ability of the external world to continue to submit good proposals. We would expect that we would fund these centers for 5 years with some Government funding. We would expect that their proposal would contain a description of a program of how they would achieve private sector funding to augment the Government funding and eventually become self-sustaining. So that at the end of 5 years the Government funding would cease.

Ms. **Meyers**. The budget that you're talking about is $30 million and—for the research and development, and $11.1 million for technology utilization.

Mr. **Gillam**. Correct.

Ms. **Meyers**. And how does that relate to last year's budget?

Mr. **Gillam**. Last year's budget for technology utilization, I believe, was $9.6 million and the 1985 request to Congress did not contain any funds for the commercial programs. We reprogrammed from other areas through the reprogramming process and a request to Congress $8½ million in 1985 to start the commercial development activity.

Ms. **Meyers**. OK, thank you.

Mr. **Gillam**. Thank you.

Mr. **Nelson**. Mr. Smith.

Mr. **Smith**. Thank you, Mr. Chairman.

Mr. Gillam, last week we had, I think, six individuals representing various firms who were interested in the commercialization of space and the testimony that they gave to this committee, I felt, was rather grim. They seemed to be very pessimistic about costs, commitments that have been made by NASA. I'm concerned about that. It seems to me that in space the people in private industry ought to be knocking our doors down. There ought to be—the opportunities seem to me to be unlimited. And I think that commitment essentially is a two-way street. It's very difficult for a business to make a commitment or company to make a commitment in space, if that commitment, in turn, is more or less dictated or directed by what NASA does, which of course, is dependent on what this Congress does in terms of funding.

How do you—how is this going to work, this two-way commitment? Does somebody have to start the snowball rolling and if so, who's going to start it? It seems to me we're going around. and around, and around here and I'm concerned that we're going to be passed by. These gentlemen indicated to me in a question that I asked one of them very directly, the answer was if we don't do something quickly we're going to go to foreign route—we're going to go the foreign route, the French and we may not be able to compete. These were American businesses. How is the commitment process going to work? Who is going start it?

Mr. **Gillam**. I think in a way we have started it in conversations. Mr. Walker asked me about our conversations with the private sector. The conversations that we've had with the private sector seem to indicate to me that the private sector, in establishing their equation for making a decision, says that that equation has many variables. You know, risk being one variable and the biggest variable within that area of risk is what they call the killer variable, is the U.S. Government. They don't know what actions the U.S. Government might take for some reason that we can't foresee today that would wreck their investment in a project once they have proceeded with the project. NASA does take into consideration its rules, and regulations, and puts that in the contract and explains to the private sector, such as the joint-endeavor agreement or other agreements that we enter into, that NASA's commitment to this agreement is subject to appropriations to be able to carry out the agreement.

Generally the Government has fairly consistently performed in terms of those types of agreements, but come 1988, 1989, for some other reeson the Government may decide that it wants to charge value of the flight, rather than cost of the flight, and you just clobbered the guys who did an analysis now on what the anticipated cost might be. So that is a problem. We have not encountered great difficulties with either the Congress or the administration like this in the past, but they worry about it.

They worry about, well, suppose in 1991 I've made this commitment to the shuttle and the space program and you decide you're not going to fly commercial business at all, for whatever reasons, so we've been asked about those. Those are concerns. We are working with them to persuade them that these concerns are not as—of the magnitude that they've talked about, but it is a hindrance to the program, to the activity.

Mr. SMITH. Has the response from industry been positive toward the centers that you've—this is relatively—this shows some good faith on NASA's part. Has the response been positive from industry? Have you had good response?

Mr. GILLAM. Oh, extremely good response from both industry, in terms of the centers and university communities. The surprise to us was that there were so many local, State, and local organizations that are concerned with business development within their constituencies and locations that participated in it as well. But, the industry and university response has been very positive and the State ad local government response startling.

Mr. SMITH. Thank you. Thank you, Mr. Chairman.

Mr. GILLAM. Thank you, sir.

Mr. NELSON. Mr. Gillam, do you have a dollar figure you'd like to suggest on the shuttle pricing? [Laughter.]

Mr. GILLAM. No, I would just suggest that whatever price we get we stick with it for awhile. That will give the business people an idea—a capability to do their planning and their analysis. I guess the figure that I would submit would have to be the official figure that the Agency has submitted to the President.

Mr. NELSON. What do you think of the view of those who testified here that said that increasing the price of the shuttle launch services will foster the growth of a U.S. commercial ELV industry?

Mr. GILLAM. I think that that's a possibility. If you're asking for a personal opinion, I'll give it. I think increasing the price of the shuttle will foster the growth of Ariane.

Mr. NELSON. All right. Let me chat with you. You have $30 million in your budget—well, I can't find my notes now. I wrote—here we go. How much of this $30 million budget is actually going to R&D?

Mr. GILLAM. I have a breakdown of it and I can give it to you: basically all of it to R&D. When you talk specifically about research, the $6½ million goes for centers of excellence is all going to R&D. There is $11.7 million for facilities and other activities, that's all going to R&D and I might clarify the use of the word facilities. What we're talking about is in-space facilities, experimental devices and other facilities like that. We're not talking about any brick and mortar or any buildings.

The NASA research with commercial interest, the $5.8 million is all R&D. The stimulating of the private sector research, $5.1 million is all R&D. Now, the areas that you might question in terms of the nature as to whether or not they are R&D, we have a half a million dollars allocated for Outreach activities. That's talking with targeted industries, such as the chemical industry, the pharmaceutical industry and trying to convince them to go into R&D with us. While it's from the R&D budget it's basically funds aimed at stimulating R&D and the economic studies, the $400,000 is for various kinds of studies that are associated with R&D, so in effect all of it is R&D. You might subtract out the $900,000 for outreach and economic studies if you wanted to be absolutely pure.

Mr. NELSON. Of the $6½ million going to the center of excellence, is NASA or industry going to decide the particular applications focus at those centers?

Mr. GILLAM. The private sector proposers will decide the applications focused at those centers.

Mr. NELSON. NASA will?

Mr. GILLAM. The private sector proposals. NASA will select the best proposal in each category.

Mr. NELSON. All right. Now, you expect that they're going to be self-sustaining after several years.

Mr. GILLAM. Yes.

Mr. NELSON. With the funding from the private sector. What incentive is a company going to have to join with other companies and NASA in a kind of mutual arrangement as opposed to setting up its own inhouse science center?

Mr. GILLAM. The basic incentive is that the research, basic research of the kind that we're talking about is usually fairly expensive and a company would have to have a very large research budget to get to such a broad range of data that will come out of the centers. We found, from the centers that are already in existence, and there's one at MIT that's very close to being self-sustaining, that was started as a part of the science program, that the private sector is very willing to make an investment in a center for basic research to provide them a knowledge base rather than do that themselves, because of the expense involved in setting it up for themselves.

They would be more interested in doing applied laboratory-type work for themselves, rather than the basic research.

Mr. NELSON. All right. Let me ask you about a budget question here. You budget is considerably more over last year, justify how you think your program is mature enough that it can realistically spend $30 million

Mr. GILLAM. It's not really a new program. What this is is the Office of Commercial Programs is a collection of activities that have already been going on in NASA and the Office of Commercial Programs is focusing those activities. If the bulk of the effort that we're going—spending our research and development budget on is material sciences work and that's an area that has been somewhat neglected or underfunded or underfocused for a fairly good period of time and what we're doing is that we're picking up and trying to give that activity a shot in the arm with a commercial focus. So, commercial efforts and activities with commercial potential have been going on in NASA for a good while. What we're doing is focusing that and providing augmentation, focused augmentation to the general material sciences, to the research in remote sensing and possibly even develop some research activity, development activity in communications. So, the programs have been there. The activities could have expanded before, but they did not have the opportunity and you will find that the majority of our $30 million is focused toward material sciences, which is intuitively the area with the greatest commercial potential, but we haven't done the research, so we're focusing on providing industry-focused research, as opposed to science-focused research in that area.

Mr. NELSON. What is the current status, Mr. Gillam, of the implementation of the national commercial use of space policy plan?

Mr. GILLAM. The implementation plan that NASA published with its policy was somewhat dated. It had all of—it assumed that the program started in January 1984. The Office was formed in September of 1984 and then we were—the policy was published in October 1984, so what we have done is we have selectively taken those 19 initiatives that were outlined in that program plan and taken those that had an R&D focus and given those a priority for implementation.

And we're reviewing the remainder to sort of work them in on what might be considered a reasonable schedule, once we've got the priority items of R&D initiated, such as the centers for development.

Mr. NELSON. All right. One area that might be utilized to stimulate commercialization is in procurement, such as in the course of a competitive procurement additional credit could be given to the systems which had been developed with private financing. All right. Is—what's NASA doing in this?

Mr. GILLAM. Well, Mr. Chairman, the policy specifically states that NASA will purchase, under some special circumstances, and I don't mean special circumstances in a normal sense, where there is a need for the Government for the commercial product and certain other criteria, specifically and explicitly stated as a part of NASA policy. It is not currently policy to give a special advantage to something because it was developed with private sector funds. We're looking at the question. There are several issues at hand. We're looking at the question of what might be done, within the rules of the solicit evaluation boards and the procurement process. As to whether or not such things are possible, that question has not been completely resolved internally. However, we do intend to make purchases where there is a Government need of items developed by the private sector.

Mr. NELSON. All right. Tell me about—how many new companies have been increased pursuing commercial space ventures, as a result of the establishment of the Commercial Programs Office?

Mr. GILLAM. That's kind of difficult to tell. I can say that we had about eight Memoranda of Understanding, JEA's, TEA's signed at the time the Office was formed. I can say that the number has probably increased to about 15 now, some of which is a result of our Office and some of which is a result of previous efforts that have already been undertaken and that I can say that we're probably in discussions for about eight more. But, it's difficult to say whether that's as a result of the formation of the Office or a result of some of the earlier effort that went on just prior to the formation of the Office. There has been a definite increase in interest.

Mr. NELSON. OK, one more question. The fifth orbiter. What has been the role of the Commercial Programs Office in evaluating private sector proposals for the purchase or lease of a shuttle orbiter?

Mr. GILLAM. We've inherited that function, so to speak. I worked previously for General Abrahamson and I was given an assignment of working with the Space Transportation Corp., of Princeton, in their initial proposal for the purchase of a fifth orbiter. As a result of that, while I was still in the Office of Space Flight, I was given the assignment of working with Astrotech in the evaluation of the Shuttle America proposal. That is kind of a task that has just come along with me to the Office of Commercial Programs and our office has had the lead in discussions with Shuttle America and Astrotech in their proposal for the purchase of a fifth orbiter. So, in my previous incarnation I had that responsibility and that just moved with me. So, we have the lead in conjunction with the Office of Space Flight, who has participation on our panel. The General Counsel's Office participates on our panel and the Procurement Office all participate on a panel we chair.

Mr. **Nelson**. Well, my question further implies, what is the status of the negotiations?

Mr. **Gillam**. I think the status of the negotiations are best responded to by saying that NASA supplied to this subcommittee, a couple of years ago, a set of criteria that would have to be met by the private sector. There were five items. I think that we have found that the latest proposal that we have received does not meet a couple of those criteria. We have informed the proposer the specifics of where that does not meet the criteria and have put the ball in his court, so to speak, as to whether or not those are critical to his proposal and, if so, he can withdraw, and if not he can continue discussions with us. I saw in the press the other day that they had announced they intended to continue discussions.

Mr. **Nelson**. OK, finally. Is this as a result of your office, that you have a "For Sale" sign up in space?

Mr. **Gillam**. Somewhat.

Mr. **Nelson**. All right.

Mr. **Gillam**. I might mention, one of the things that is a result of our office is the excellent article in this week's Aviation Week on protein crystal growth. That's one of the areas that we are very excited about and we feel has a great deal of potential.

Mr. **Nelson**. OK, and without objection we will have unanimous consent to the witnesses to respond to the written questions where it has been indicated here in the hearing.

Mr. Gillam, we appreciate it. The meeting is adjourned.

[Whereupon, at 11:30 a.m., the subcommittee recessed, to reconvene at the call of the Chair.]

1986 NASA AUTHORIZATION

TUESDAY, MARCH 5, 1985

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:03 p.m., in room 2318, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. NELSON. Good afternoon. We're delighted to have all of this interest in a subject that is sometimes dull, but really most interesting.

And so today we're going to hold the second of 2 days of hearings on the subject of the space shuttle pricing policy. In other words, what should be the price to commercial and foreign customers for shuttle launches in 1989 through 1991?

A week or so ago, in our first hearing, we heard from representatives of the industries that will be most directly impacted by a Government decision on this issue. Our witnesses at that hearing included individuals from the commercial launch vehicle community, as well as several segments of the user community, including communications satellite builders and operators, upper stage manufacturers, space platform builders and operators, and materials processing companies.

Now, today, we're going to have the testimony from Government witnesses. Our objective on this subcommittee is to gain a fuller understanding of the views of these two Federal agencies that will be most affected by the space shuttle pricing. We'll receive testimony regarding the space shuttle pricing study, also, that was recently completed by the Congressional Budget Office. They've done a lengthy study, just out, and so we're looking forward to receiving testimony on that.

The witnesses are the Honorable Jim Beggs, Administrator of NASA; Ms. Jenna Dorn, the Director of the DOT Office of Commercial Space Transportation; and Dr. Eric Hanushek. He is the Deputy Director of the Congressional Budget Office.

I'd like to thank each of you in advance for being with us today, and I really appreciate you participating in this important topic.

Since my ranking Republican member, Mr. Walker, is not here at the moment—he's on his way—we'll have an opening statement by him that will be made a part of the official record, without objection.

[The prepared opening statement of Mr. Walker follows:]

OPENING STATEMENT FOR
HON. ROBERT S. WALKER
STS PRICING POLICY HEARING
MARCH 5, 1985

GOOD AFTERNOON, MR. CHAIRMAN. OUR ISSUE TODAY IS ONE OF THE MOST CRUCIAL THIS SUBCOMMITTEE WILL FACE THIS YEAR.

I HAVE BEEN ONE OF THE MOST VOCAL SUPPORTERS OF THE COMMERCIALIZATION OF SPACE. IN FACT, THE MEMBERS OF THIS SUBCOMMITTEE HAVE CONSISTANTLY PUSHED NASA AND THE AEROSPACE INDUSTRY TOWARD MORE VIGOROUS EFFORTS IN THE COMMERCIALIZATION ARENA.

AT LEAST SO FAR, WE HAVE BEEN DISAPPOINTED BY THE LACK OF COMMERCIAL SUCCESSES. OVER THE PAST FEW YEARS WE HAVE HEARD MANY WITNESSES ASSURE US THAT THERE IS A GREAT POTENTIAL FOR DOMESTIC ELVS, BUT WE STILL DO NOT SEE THAT MARKET DEVELOPING.

WE ARE STANDING AT THE THRESHOLD OF A NEW ERA OF ECONOMIC GROWTH BASED ON THE COMMERCIAL EXPLOITATION OF SPACE. THERE IS A CHASE ECONOMETRIC STUDY WHICH INDICATES THAT THERE IS A POTENTIAL FOR A $1 BILLION SPACE BASED ECONOMY BY 2010. A RECENT HERITAGE FOUNDATION STUDY INDICATES THAT OUR SPACE BASED ECONOMY COULD GROW TO $4.5 BILLION BY 2050.

I BELIEVE THAT THOSE FIGURES ARE ATTAINABLE IF WE MOVE SWIFTLY TO REMOVE INSTITUTIONAL AND ECONOMIC CONSTRAINTS AND TO REMEDY A NUMBER

OF INEQUITIES IN THE TAX CODE.

IF WE ARE TO SEE THE KIND OF ECONOMIC GROWTH I ENVISION, I THINK WE WILL NEED A BALANCED SYSTEM OF ACCESS TO SPACE WHICH WILL BE MADE UP OF BOTH THE SPACE SHUTTLE AND A FLEXIBLE GROUP OF EXPENDABLE LAUNCH VEHICLES.

TO REACH THAT CAPABILITY, THIS SUBCOMMITTEE WILL HAVE TO CAREFULLY BALANCE THE VALUE OF THE STS, THE NEEDS OF THE USER COMMUNITY, AND THE VIABILITY OF THE DOMESTIC ELV INDUSTRY.

OUR WITNESSES TODAY WILL HELP TO PROVIDE US WITH THE INFORMATION WE WILL NEED TO REACH OUR DECISIONS. IT IS ONE WE WILL APPROACH WITH GREAT CARE, SINCE THIS DECISION WILL BE THE MOST SIGNIFICANT CHOICE REGARDING SPACE POLICY FOR THE REMAINDER OF THIS CENTURY.

Mr. NELSON. I will call on Mr. Lujan, who is the ranking member of the full Science and Technology Committee.

Mr. LUJAN. Thank you, Mr. Chairman.

Shuttle pricing policy, and the effects of a change in the price NASA charges customers for a dedicated payload bay, are policy issues of profound importance to the future of space commercialization.

There is no simple way to determine what the shuttle pricing should be. There's no easy way to balance the interests of the expendable launch vehicle industry against the interests of companies who have designed their entire programs around the low-cost access to space provided by the space shuttle system.

Of the companies which are shuttle-dependent, some have invested millions of dollars in developing shuttle-based technologies. Others, like the McDonnell Douglas Corp., have invested hundreds of millions of dollars and thousands of man-years developing new products and processes for space. In many cases, these are processes which can only be done on the shuttle, and products which can only be used on the shuttle.

For most of the shuttle-unique payloads, a steep rise in the cost of using the shuttle would spell financial disaster. Many of these companies would either stop developing new products or simply go out of business, depending on the scope of their business. Events like these would spell disaster for the entire enterprise of space commercialization and doing business in space.

If we raise the shuttle price high enough, we could even drive our long standing commercial customers—the satellite builders—right into the arms of foreign launch competition. This is obviously not a policy stand we want to take.

As a nation, we have already invested over $15 billion in our space transportation system. The space shuttle system is obviously a valuable national resource and a critical enabling technology for future space industry and space business.

It is not appropriate to encourage the Government to compete with the private sector to provide launch services for commercial payloads. It is not appropriate to stack the deck so that when the Government and private sector do compete, the Government always wins. It is also not appropriate to take action which might cripple our fledgling space industries in the long term.

We must carefully weigh the long-term implications of any policy decisions we make regarding the future role of the shuttle in space commercialization.

These hearings, Mr. Chairman, and specifically today's hearings on shuttle pricing policy, will help us make balanced policy decisions which will promote, rather than inhibit, space commercialization and American enterprise in space.

Thank you very much, Mr. Chairman.

[The prepared opening statement of Mr. Lujan follows:]

OPENING STATEMENT FOR HON. MANUEL LUJAN, JR.

Thank you, Mr. Chairman.

Shuttle pricing policy, and the effects of a change in the price NASA charges customers for a dedicated payload bay, are policy issues of profound importance to the future of space commercialization.

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For most of these "shuttle unique" payloads, a steep rise in the cost of using the shuttle would spell financial disaster. Many of these companies would either stop developing new products or simply go out of business, depending on the scope of their business. Events like these would spell disaster for the entire enterprise of space commercialization and doing business in space.

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We must carefully weigh the long-term implications of any policy decision we make regarding the future role of the shuttle in space commercialization.

These hearings—and specifically today's hearing—on shuttle pricing policy will help us make balanced policy decisions which will promote, rather than inhibit, space commercialization and American enterprise in space.

Mr. NELSON. Thank you, Mr. Lujan.

Mr. Beggs?

STATEMENT OF JAMES M. BEGGS, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. BEGGS. Thank you, Mr. Chairman, members of the subcommittee. I am pleased to be here to present my statement on the costing and pricing issue.

The President has directed that a pricing plan for full cost recovery for space shuttle operations in the post-fiscal year 1988 period be developed. This activity will have a broad impact on the U.S. maintenance of its role as the world leader in providing transportation to space. There have been many times that we have been faced with such critical decisions during the development and evolution of the Nation's Civilian Space Program. This is one of those times.

We can look with pride to what this Nation has accomplished in space, thanks to prudent decisions. We planned and successfully accomplished challenging feats, such as landing men on the Moon, exploring the planets, and developing the shuttle. We have also been instrumental in the development of communications satellites, expendable launch vehicles, weather satellites, and satellites used for mapping Earth resources. We are now looking forward to new challenges, like planning the development of the space station and the further involvement of the commercial-private sector in space.

NASA has always been the world leader in space science research, space transportation, and the spinoff of high technology to assist domestic industry to maintain its competitive edge. We now see emerging strong and vigorous competitors for the world's space business, including satellite manufacturing and space transportation. We intend to continue to compete vigorously and successfully, using the space shuttle transportation system to meet existing launch needs and to stimulate whole new industries. Some experts predict that by the year 2000 this space business will grow to $60 billion per annum, with over $40 billion in materials processing, $15 billion in communications, $2 billion in on-orbit services and Earth-remote sensing, and $1 billion in launch services.

We are at a crossroads in our decisionmaking process, which will have impact in key areas through the end of the century. In addition to providing almost three-quarters of a million jobs, the aerospace industry has been one of the outstanding performers in our balance-of-trade picture. For last year, aerospace exports exceeded by over three times the value of imports. Overall, the industry contributed over $10 billion in trade surplus to help alleviate our balance of payments deficit.

Fundamental issues are being debated that impact not only expendable launch vehicles and the shuttle programs, not only NASA and Arianespace, but also the existing commercial space industry. This industry is comprised of shuttle upper stage and component manufacturers, satellite and platform manufacturing companies, such as Johnson & Johnson—excuse me, satellite and platform manufacturer companies such as Johnson & Johnson and 3M, which are seeking to develop new industrial processes dependent on space shuttle flights, and entrepreneurs hoping to privatize the ELV's which NASA will be discontinuing. The question of shuttle pricing also impacts the U.S. tax base, revenues to the U.S. Government, the U.S. balance of trade, and, most importantly, the American taxpayer.

The President has directed that NASA's first priority is to make the STS fully operational and cost effective in providing routine access to space. We are also working to implement the administration's goals for the commercial development of space. We are intent on ensuring that we help provide the opportunities to American industry so that they can compete effectively and we can retain as a nation the substantial share of the forecasted $60 billion commercial space business of the future.

That concludes my statement, Mr. Chairman. I'll be happy to respond to questions.

[The prepared statement of Mr. Beggs follows:]

Statement of

James M. Beggs
Administrator

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

The President has directed that a pricing plan for full cost recovery for Space Shuttle operations in the post-FY 1988 period be developed. This activity will have a broad impact on the United States' maintenance of its role as the world leader in providing transportation to space.

There have been many times that we have been faced with critical decisions during the development of the Nation's civilian space program. This is one of those times.

We can look back with pride over this Nation's accomplishments. From the first Mercury flight, through the landings on the Moon and the scientific exploration of the planets, to the development and successful flights of the Shuttle. We can also point with pride to the development of the communication satellites, the expendable launch vehicles, the tracking and data relay satellites, the weather satellites, and satellites we use for mapping the Earth and scanning her resources.

We are now looking forward to the development of the Space Station and the further commercial development of space. For years we have been the world leader in space transportation. We have cooperated with our foreign allies and now see one of those nations emerging as a very strong and vigorous competitor for the free world's space launch business. We also see other nations beginning to compete in the satellite manufacturing business and can foresee the day when competition in this area will also be more vigorous.

The American space business, today, is one of the bright spots of our economy. It is alive, healthy, and growing. The Center for Space Policy predicts that by the year 2000, only 15 years away, that space business will grow to $60 billion, with over $40 billion in materials processing in space, $15 billion in communications, $2 billion in on-orbit services and remote sensing, and $1 billion in launch services.

We are at a critical point in our decision making process which will have impact not only in the next decade but probably beyond the year 2000. The problems are difficult and there are no easy answers. Fundamental questions have been raised which can impact not only expendable launch vehicles and the Shuttle, not only NASA and Arianespace, but also the existing commercial space industry. This already existing industry is comprised of Shuttle upper stage and component manufacturers, satellite manufacturers, companies, such as Johnson & Johnson and 3M which are seeking new opportunities in space, and entrepreneurs hoping to privatize NASA's ELV's, which are being discontinued. The question of Shuttle pricing also impacts the U.S. tax base, revenues to the U.S. Government and, most importantly, the American public, our balance of trade, and the future potential of the American Space industry.

NASA is deeply committed to the President's policy to commercially develop space, and can point with pride to the work we have already done in this area. In addition to providing almost three quarter of a million jobs, the aerospace industry has been one of the outstanding performers in our balance of trade picture. In the last year, aerospace exports exceeded by over three times the value of imports with the space program contributing significantly to our favorable export picture. Overall, the industry contributed over $10 billion in trade surplus to help alleviate our balance of payments deficit.

The President has directed that NASA's first priority is to make the STS fully operational and cost effective in providing routine access to space. He has also directed that the STS program will receive sustained commitments by all affected departments and agencies and directed that enhancments of STS operational capability, upper stages and efficient methods of deploying and retrieving payloads will be pursued as national requirements are defined.

We are working intently to implement the President's goals for the commercial development of space, and, while pointing with pride at the past, are deeply intent on insuring that we help provide the opportunities to American industry so that they can compete effectively and we can retain, as a Nation, the substantial share of the forecasted $60 billion in the year 2000.

I will be happy to answer your questions.

Mr. NELSON. Thank you, Mr. Beggs. That's the shortest speech I've ever heard you give. [Laughter.]

Mr. BEGGS. It may have been the shortest.

Mr. NELSON. I might underscore a part of that. Recently it has come to my attention that our trade deficit has now grown to—I think it's $163 billion, our trade deficit, in 1 year. And you point out that aerospace exports have exceeded imports to the tune that we are contributing $10 billion to our balance of payments in a trade surplus. And I appreciate you sharing that with us.

Mr. Beggs, are we going to be able to make, in the early 1990's—1989, 1991—are we going to be hitting that launch rate capability of 24 a year?

Mr. BEGGS. I believe we will, Mr. Chairman. It will require some continual improvement in our turnaround times and our ability to launch on schedule. We've had some much-publicized delays in the last couple of months which, while I view those delays as serious—we view any delay as serious—I also view them as normal growing pains for this stage of our development of the shuttle system.

One has to remember that what we have here is an entirely new system. It is something that was conceived about 15 years ago, and when it was conceived, we didn't have all the answers to the operational problems so we're learning as we go along. As we learn, we're improving, and we're getting pretty good at the business of turning around. What we are running into from time to time are the unforeseen problems that will crop up in the early stages of any program.

Mr. NELSON. Indeed, you—meaning us, the Nation as a whole—have put together this fantastic flying machine. There were certain requirements, designwise, that were placed upon NASA by the Air Force. In developing this machine, there was an abundance of caution that was used in its design since we were on the cutting edge of technology; we wanted to be abundantly cautious as we designed it that it could do what we wanted it to, so what we've done is a big research and development project to build the machine.

Now, as we get operational, we know more and more about it as we are flying it. Is that correct?

Mr. BEGGS. That's correct, Mr. Chairman. And, it is important to note, I believe, that the higher flight rates are almost essential to the full development of this system. The reason for that is that the more we fly, the more we will be able to fly. The more we fly the shuttle system and learn all of the various problems and idiosyncrasies of the system, the wider we open the envelope, as we say in this particular trade, the better off we will be for the future. The better off we will be for the future to continue to fly the current generation of the shuttle, and the better off we will be in the future to design, eventually, a second generation shuttle system.

Mr. NELSON. Now, I would interpolate, from your comments, that we're knowing more and more as we fly more and more in two areas. We know more and more how to design a system so that it becomes more cost effective, and at the same time we know more and more how to use our people to be more cost effective.

So my question to you, you've got this vast marching army of folks that support this program. Now, are you saying to us that as you get the launch rate up, you're going to be able to continue to become more efficient over time since you are using that same pool of people to operate it with?

Mr. Beggs. Yes, sir. The economics of a launch system are really quite simple. The major portion of your costs—I'm talking about operational costs now, not the capital costs—the major portion of the operational costs are fixed over a period of time. If you look at 1 year's time period, or even a 2-year time period, the costs that are built in, such as that army of people that you need there whether you're launching a half a dozen times a year or 20 times a year, the facilities that you need to have in place and the inventory that you have to have in place to launch those vehicles, the necessary support that goes behind that all the way back to the factory is a constant, or a near constant. Nothing is constant, but a near constant. And, therefore, the more times you fly in any given period of time, the lower the costs are; and also, the more times you fly each year the more efficient you've become.

If you look to the past in our experience with expendable launch vehicles, the one we've flown the most number of times is the Delta vehicle. We found that as we learned how to fly the Delta and as we learned how to fly it a number of times, we could do two things, both of which were important, among other things, but two important things. First of all, we could cut down the number of people that we needed to service the vehicle and get it ready for launch. Also, the launch crew itself, and we found that when it was necessary we could surge and launch more times in a shorter period of time. I believe the record shows that we launched three Delta vehicles within a 31-day period, or a 32-day period. I won't say that we could have done that for a full year, but we did launch 12 in a year, and we could no doubt have launched considerably more than that.

The same is true of the shuttle. As we learn, we will be able to surge and we will drive the cost down.

Mr. Nelson. Before I turn to Mr. Walker, let me ask you that—over the course of the weekend I remember seeing a story about part of the discussions that you had with the Air Force through Pete Aldridge and others that has culminated in this agreement with regard to the Air Force flying at least one-third of your missions each year, one-third of the shuttles. There was also mention about NASA and the Air Force cooperating together as we look to what is going to be the follow-on to this generation of shuttles.

And so my question to you, as the Administrator of this program, is, how valuable is it to you, as Administrator, to continue to drive that marching army that you have now to become more efficient with those higher launch rates so that you're building a base of experience in knowing what you want when you get ready to go into the next century with some follow-on to this generation of shuttle?

Mr. Beggs. I think it's vital that we do that so that we understand fully the abilities and the capabilities of this machine to fly.

I think it's also vital if we are to understand the options for the future. We will, no doubt in the 1990's, require a heavy lift vehicle in this country. It's almost a certainty now, but I think it will become increasingly clear as the next 3 or 4 or 5 years pass by, as we start to think about what we want to do in space. We will require a heavy launch vehicle.

The technology of the shuttle is the most modern technology we have. It is current state-of-the-art and it does provide, therefore, the technological base upon which we'll build into the 1990's. To the degree we understand it completely, we will be able to design those better systems in the future. And the study that we intend to enter into with the DOD will explore the various options for the 1990's, both in the nature of a heavy lift ELV and also for looking at manned systems that will follow on to the shuttle. So, we'll need every bit of the technical knowledge that we will get as we fly this machine more and more.

Mr. NELSON. So these studies are to look at all capabilities—maybe manned, maybe unmanned?

Mr. BEGGS. Yes, sir. I do think that our experience in the last—well, since we started flying the shuttle, in the last 4 years—has said to us that for some uses, the ELV's, particularly when you look at heavy lift capability, the ELV's present some interesting advantages. And I think you're going to want to have them around in the future, all the way out as far as we can see.

You can lower launch costs even more than we have discussed with the shuttle or even with the current series of ELV's to cost-per-pound, which will make it economical to do a lot of the interesting things we want to do. In addition to that, of course, we have found in flying the shuttle, in the last 4 years, that the presence of human intelligence in space is extremely important, and we're finding as we expand the capability envelope of the shuttle that our ability to use human intelligence, to go out and rendezvous and pick up satellites, to repair satellites on orbit, to do useful work in interacting with our experiments in space, to develop the capability eventually to stage from low Earth orbit, to think about using means of transferring to higher orbits—again, with human intelligence—is something that would just open up a world of new opportunities and will make it possible for us to do many of the things that we've been dreaming of for the last 25 years.

Mr. NELSON. Mr. Walker?

Mr. WALKER. Thank you, Mr. Chairman.

Let me explore with you a concept here on pricing policy, and I basically want to find out from you where the problems are.

What if, instead of fixing a firm price for you in terms of policy, what we would do is give you a range of prices that you could charge that would range from, say, your marginal cost—your low marginal cost—to your fixed cost minus development? And say, in that policy, your price has to be somewhere in between those two; but depending on the kind of payload that you are carrying, probably as recommended by your Office of Commercial Development, that you would have to set your prices differently based on whether or not there is a national interest in economic expansion for, say, something that's going to be flown at a low marginal cost versus another kind of payload, say a communications satellite, that could go aboard an ELV that you would have to fix a higher price on in shuttle? Tell me where the problems would be on that kind of policy.

Mr. BEGGS. Well, I don't know that there would be a problem if that were the policy decision. The past practice and the policy we've been following is that we would set a single price and charge a single price for all comers, whether they be military payloads or whether they be civil Government payloads, foreign payloads, or commercial payloads. So that anyone that showed up in the door was assured of a single price.

That policy has some advantages in that anyone who sets out to build a satellite—and we've got to keep in mind that spacecraft are expensive; a modern communications satellite can cost, these days, anywhere from $50 million to well over $100 million—so when you make that kind of capital commitment, you would like to have the assurance that you can count on a launch cost which is fixed so that you know what your total financial commitment is at any given time.

Now, if you were to set a range of prices which would vary depending on the payload, you would, of course, I think have to give some kind of a signal to the various classes of customers as to what range would apply to them so that they could do their planning, and——

Mr. **Walker**. Why couldn't it be bidded?

Mr. **Beggs**. Well, of course, we could. I would make this point, though, if I may, Mr. Walker, that from the point of view of equity—if I can use that word—it costs less to fly a commercial communications satellite than it does a highly complex, massive payload like, let's say, the Galileo spacecraft to Jupiter or the Ulysses spacecraft to the Sun. Those are much more complex missions, require more ground support, are more complex to manifest into the shuttle. So from the point of view of equity, I think the communications and other commercial satellite manufacturers and operators would say that if you're going to price on a value basis, that their price ought to be lower. They should be at the low end, and maybe the more highly complex NASA payloads should be at the high end.

Mr. **Walker**. Well, the fact is that for a lot of those loads at the present time there is a competitive market, or there may be a competitive market. And so we've got to be somewhat responsive to that, and plus the fact that it seems to me that there's a disadvantage in setting costs, too, and that is with competition from Ariane. It gives Ariane the target price at which they come in just below. So that if you had a flexible range of pricing, that you would have Ariane, it seems to me, have to become far more competitive in the marketplace if they didn't know precisely what was going to be the price at the time that it was bid. And, you know, we overcome that disadvantage by not having a set price there against which the whole world targets—maybe Japan, at some point in the relatively near future—that we would become a part of an operating commercial market at the present time, and still leave ourselves the flexibility to fly payloads that are commercially oriented but not yet proven at a price somewhat lower if they have some real national advantage at some time in, say, the midnineties.

Mr. **Beggs**. I suppose. In the real world, however, having lived in this environment for quite a few years—that is, the Government environment—the U.S. system is much more open than the system under which the French and Arianespace, which is a private corporation admittedly owned by several governments in Europe, but nevertheless private. So that our pricing strategies in various cases, I believe, would soon become a matter of public record, and they would know. Besides which, I think that it's quite likely that for the foreseeable future we will be the price leader. And necessarily the price leader is a price that becomes generally known in the marketplace.

I'm not quarreling with the strategy you've proposed; I'm just saying that the likelihood of our being able to operate in a competitive marketplace without their knowing pretty well what it is we're going to bid—that doesn't concern me, really, that they know that. What does concern me is that we be able to price our product at what I consider to be a competitive level.

Mr. WALKER. Well, I think that's true. And my only point is, I think when you get to, say, the early nineties or at least the mid-nineties, it may well be that, for instance, for flying commercial satellites or communications satellites, that there will not be sufficient payload space aboard the shuttle to fly a lot of those; that in fact, they are going to have to go to some other market, to the ELV market, to Ariane and a lot of these places just to find space. And at that point it seems to me that your price should be flexible enough to understand that the price is what the market dictates the price will be. And if we're lowballing that price, then in fact we're probably losing the taxpayers' money at that point. It seems to me that a price policy that would be reflective of that would have some value.

Mr. BEGGS. Yes, sir. And if I thought there was a capacity limitation, I think I would change a lot of the views I had. Unfortunately, I don't think that's so. The Ariane itself, I think, has in being or is creating right now the capacity to fly the entire market. In addition to that you have the prospective entry of the Japanese into the marketplace. They are coming fast, and they will be there within the next 3 to 5 years. We have always had the Soviets in the marketplace, and lately they've become more active. They have, for example, indicated that they will bid on the Inmarsat—the International Maritime Satellite procurement. They have already announced their intention to bid on that launch service contract. And then beyond that, you have the People's Republic of China which is developing an ELV, and they have also announced that they will offer that at some point in the future for sale in the international marketplace. And, Lord, we even have the Indians talking about creating a launch capability. There's going to be a lot of capacity out there.

Mr. NELSON. Mr. Beggs, we are going to recess here to go vote. It is a quorum call, a recorded quorum with a possible recorded vote on the Senate amendment concerning African relief. Immediately after the recorded votes, we will resume the hearing with Mr. Walker's questioning.

[Recess taken.]

Mr. NELSON. We will resume questioning. What's going to happen—over on the floor there are 15 more minutes of debate before they take a rollcall on a Senate amendment to a House vehicle. So I decided to come back on here and continue the hearing, but most of the Members are staying, hanging back for that vote. So let me just continue with the questions, and I'll recognize Members as they come in.

What do you believe, Mr. Beggs, to be the total size of the annual foreign and commercial communications satellite launch market over the next 5 years?

Mr. BEGGS. I can give you our best guess on that, using the best figures we have available to us at the present time.

We see, in the 1986 time period—and we can document this for you, if you'd like—in 1986, that is the year after this, roughly 20. And I'm including both foreign and commercial, those that will be up for bid in general. And 3 of those, 3 of the 20, are potential slips into a subsequent year, and maybe some more of them. As you know, the current situation in the commercial satellite market is a bit unsettled in that there are a number of unused transponders on orbit at the present time which are for sale. Indeed, if you want right now, you can buy a whole satellite that is up for sale. So until that capacity is soaked up, until the demand catches up with the capacity, a number of the future communications satellites which are scheduled for launch could slip because of that current oversupply.

So 20 we see in 1986, and 3 of those we see as very likely slips. In 1987, we see 12; and then in 1988, we see 10. It's not surprising that the numbers go down in the future years because some folks who are going to enter the market probably haven't announced, but that's the way we see it. And of those 88, 5 are kind of soft.

Based on our current assessment of the market, we see 15 to 18 per year in the out years beyond that. And that's, as I say, our best guesstimate looking at the market, and adding up all those people who have made inquiries to us in the recent past.

Mr. NELSON. All right. What percent of those payloads are in the Thor-Delta class and what percent in the Atlas-Centaur class?

Mr. BEGGS. Well, as you move out in time, more of them move beyond the capabilities of the Delta. The larger satellites currently being planned by Intelsat are beyond the Delta. Many of the satellites that are in plans for 1987 and beyond are beyond the current Delta capability. Anything that flies on a PAM D-II or larger, upper stage, is pretty much beyond the lift capability of the Delta. So as you move out in time, more of the satellites get beyond the Delta—not beyond the Ariane, however. The Ariane is a more capable launch vehicle than the Delta launch vehicle.

Mr. NELSON. All right. Let's take that. What percentage of that overall market do you believe can be accommodated by the Ariane with those facilities that are either now in place or under construction?

Mr. BEGGS. Well, really, the whole market could be covered by the Ariane.

If I may, Mr. Chairman, I'd like to discuss the Ariane capability in a little detail.

The current capability of the Ariane is one launch pad at Kouron, and another launch pad under construction. The current launch pad is one that was originally built for the Eldo-2 vehicle and modified for Ariane, and it has the capability of launching the Ariane 1, 2, and 3 vehicles. The capability is at least—and I use that term advisedly—at least six per year. As I stated earlier, we, during the Delta days, by doubling up on crews and by using all of the facilities that are available to you, you can clearly launch several more than that simply by working harder, if you will. We launched 3 Deltas in a 31- or 32-day period at one time. So you can increase that launch rate over a short period of time. So, I think six per year, minimum; probably they could up that to eight or nine if they really wanted to.

They have under construction a second launch pad, which has the capability of launching all of the vehicles up to the Ariane 4, and that facility is designed in two zones. There is a launcher preparation zone, and then a launch zone. That means they can have a vehicle in preparation while they are launching a vehicle on the pad, so that the result of that is that they can no doubt launch at least 12 per year from the new launch pad.

So, between the two—and that launch pad, incidentally, will be on line in the year or two—they will have the capability for at least 18. Each of those vehicles, or the larger of those vehicles, is capable of putting two satellites into orbit, so they would have the capability of up to 36 satellites a year, and they have a commitment to ESA, in consideration of the fact that ESA built and paid for the launch facilities as well as developed the launch vehicles for them, that they will guarantee ESA two launches per year at least, so that means that with the capability for 18 they could launch commercially 16. And since the market for commercial satellites is, by our estimates, not likely to be much more than 20 per year, they would have excess capacity themselves to take the whole market.

Mr. NELSON. So they could take the whole market. All right.

Now, of that overall market—before I get back to Ariane—what percentage of it can be accommodated by the shuttle?

Mr. BEGGS. I think that if there were 20 per year, we can launch three current generation communication satellites—in fact, we have already launched three from one flight—we can launch up to three on any given flight, so with a commitment of 7 or 6½ shuttle launches, which is considerably less than one-third of our capacity, we could handle the entire market ourselves.

Now I should hastily add, Mr. Chairman, that some of those satellites are much larger than current generation, so probably we're talking about using a third of the capacity of the 24 a year rate, or 8 per year, and we could probably handle the entire market.

Mr. NELSON. All right.

I wanted to clarify that because, you know, in the rumor mill it goes around that the shuttle is so heavily booked that NASA cannot accommodate the foreign and commercial market. And so you're saying that's not true, that the shuttle can accommodate the market.

Mr. BEGGS. Well, there have been a number of discussions of this particular point. Most of them go back to the projections we made of flight rates several years ago. The flight rate we projected in the mid-1970's, as this committee knows, was much higher than what we're flying, significantly higher. And, the anticipation was that we would build up more rapidly to a high flight rate, and therefore it is projected that NASA is going to be "too busy" to handle the commercial market.

The plain facts are that we are flying everything that's been offered us. We're flying the market that has been offered to us to fly, with the number of flights we have projected. This year, as you know, we had 12 flights scheduled. We just lost one; we hope, therefore, to launch 11. But that pretty well handles the market that we are able to capture.

Mr. NELSON. All right, let me underscore that. You said in the last year, how many times have you been in head-to-head competition with Arianespace?

Mr. BEGGS. Well, in the last year we've been in competition something like, I think, 10 times.

Mr. NELSON. And how many did NASA win?

Mr. BEGGS. We won about half.

Mr. NELSON. All right. Now, these are at the current——

Mr. BEGGS. We're about on a 50-50 basis with them on the overall market right now.

Mr. NELSON. All right. Now, this is at the base rate of $71 million per dedicated flight; is that correct?

Mr. BEGGS. In the current pricing period, yes, sir. In the 1986, 1987, 1988 time period, we're at a price of $71 million, in 1982 dollars. You have to escalate that to the time period in question.

Mr. NELSON. In 1982 dollars? OK.

If you raised that fee, then, and I've heard a figure bandied around of $87 million—so if you raised that fee from $71 to $87 million per dedicated flight, what do you believe would be the result of future competitions with Arianespace?

Mr. BEGGS. Well, if I believe Ariane, they claim that they will probably follow us up. On the other hand, if I look at the marketplace, I've got to be worried that if we raise it significantly higher for the commercial market, that we'll lose a larger percentage of the marketplace. But I don't know that until we've tested the market. We do know that at the present price, that we're capturing about half. Arianespace has complained publicly, as well as privately, that their prices are too low. I'm not sure what that means because in several of the most recent competitions they have been significantly below our current pricing. But if they continue to undercut, this is a very price-sensitive market, the commercial satellite business is a very price-sensitive market. And if they cut significantly below us, we'll lose more—a larger percentage of the market.

Mr. NELSON. Well, in this head-to-head competition where they got about 50 percent, what has been the price that they've been charging, compared to the $71 million per dedicated flight in 1982 dollars that we've been charging?

Mr. BEGGS. Well, I can't relate it quite that way. If I may, Mr. Chairman, let me relate it this way.

That $71 million translates to a price of about $26 to $27 million for a PAM D class payload. And, the reason there's a bit of range there is that it depends on which optional services the customer picks up that sets the exact price. But compared to that price, Ariane has bid as low as $20 million for a similar payload. They have also bid as high as our price. In short, they have tended, over time, to bid low where they wanted a particular payload to fill a gap in their manifest, and bid with us on one that didn't make all that much difference to them.

So they've priced to the market and to the time period, and have gone as low as $20 million and as high as what we have been.

Mr. NELSON. Let me talk about the Ariane engine——

Mr. BEGGS. They've even bid slightly higher in some competitions.

Mr. NELSON. All right. Thank you.

The Ariane engine—we understand there's a limitation on Ariane production rates, and that's it's engine production capability. What do you think—how much of an investment would be required by Arianespace to substantially increase Ariane engine production rates?

Mr. BEGGS. Well, that investment is not large for the technology they're pursuing, maybe $50 to $75 million in the current capability. However, I would add this to that, Mr. Chairman, that they have experienced the same kind of start-up problems and learning curve problems that everybody has. They will achieve a higher production rate on engines as a result of learning curve efficiencies as time goes on.

It is clear that they are gearing up for a fairly high production rate. We recently had the opportunity to visit their plant outside Paris, at Evry. There is a large plant of Aerospatiale where the vehicles themselves are assembled, and that plant—it's called Les Mureaux—has seven check-out bays. The time that you spend in a checkout bay is less than 2 months for a vehicle. That says that you have a capability of building 42 vehicles, so they're clearly facilitizing for a high production rate. At the time of the visit they were only using three of those bays; but, as you can see, they are facilitized for a much higher rate.

They currently have on order a fairly sizable number of vehicles. They have 29 vehicles ordered, total, at the present time, and they have ordered long lead-time supplies, long lead-time procurement items for another six vehicles. That's at the present time. And, the 29 is, I think, what they see as their share of the market because they wouldn't build those vehicles if they didn't see that much market.

Mr. NELSON. Where I'm trying to go is, looking at a hypothetical that if we were to substantially raise our launch fees—I'm trying to predict what the French would do. Would they make the necessary capital investments in order to be able to expand Ariane and ultimately to try to capture a larger portion of the satellite launch market?

Mr. BEGGS. Well, I have a hard time putting myself quite in the shoes of the French market people. But, I think if I were in their position, what I would do is to maximize my capture rates so as to most fully use my facilities. And I would, at the same time, try to maximize my return on that. As I said earlier, the economics of launch systems are really very simple. The major costs are the fixed costs and the more times you can fly, the lower your cost per launch becomes. So in looking at that, I would look at what my incremental cost of flying would be and then I would seek to bid accordingly into the marketplace, trying to fill that manifest; and as I got to the point where I was 50 to 75 percent filled, then I would raise the price accordingly to fill the rest at higher prices so as to maximize my return. As I said, if you look at their pricing strategy over the last year, it appears that they're following a strategy of that sort. They bid low to fill up the gaps in the manifest, and then where they didn't particularly need a launch time period, they'd bid relatively higher. It's a good strategy.

There's another strategy, pricing strategy, that I would also look closely at, since both their satellite producers and their companies that produce the launch vehicles and the launch service company itself are all Government owned. They're owned by the several European governments so they can bundle, if you will, which we would have a relatively harder time doing. And, indeed, we see them starting to do that, or at least moving in that direction; that is, they would offer to a customer the opportunity to buy a satellite and the launcher and launch service in one single-price proposition, and probably could thereby reduce the total cost that the satellite operator incurs to both buy and service the satellite. So what they are moving toward, and I think we'll see this developing as time goes on, is that bundling of the marketplace.

They have, for example, designed and are developing a number of what they call "spacebus satellites." These are various size busses into which you can put electronics for any functional use. Those spacebusses are designed specifically to fly on Ariane, and they cannot necessarily be made dual-compatible—at least, it's not their intent to make them dual-compatible—so that if you buy into that kind of thing, whether you get a single price or not, you're sort of constrained to fly on Ariane. Now, if they succeed in that strategy, then the advantage they will get—and that's why they are desirous of doing that kind of thing—is that they will then fall heir to the ground services and ground equipment market, and the ground equipment market is 75 percent of the total. So it's that total market that they're looking at, and since they are all basically controlled by a single entity or basically designed by a single entity, they will no doubt be looking at that kind of pricing strategy.

Mr. NELSON. All right. The committee will stand in recess until we have this vote, and there's about 5 minutes left on the vote. We'll be right back.

[Recess taken.]

Mr. NELSON. The committee will resume.

Mr. Lujan, before I recognize you let me finish that final question on this train of thought that I was going with here.

If you could pick a competitive number, in your opinion, to be competitive with Ariane, do you have a figure?

Mr. BEGGS. Mr. Chairman, about all I can say on that is clearly that we are sharing the market with Ariane at the present price, that is, $71 million in 1982 economics, so clearly we are competitive at that level. We'd like a larger share of the market, and I'm sure, so would they; but that's where we are. So, I think $71 million is competitive in the market environment we face today.

When you look to the future, if we raise the price to the point where we will perhaps do two things—one, go significantly higher than the Ariane costs, and two, get to a price where the satellite operator starts to look at the total cost of getting a satellite in orbit and operating, get noncompetitive or significantly less competitive vis-a-vis the earthbound telecommunications facilities, such as fiber optics and land lines and microwave—then we will price ourselves out of the market and the market will go to anyone who comes in and offers them a price that's below that. I don't know where that is. All I know about Ariane, for example, is what they've said publicly; the most recent statement they've made is that the current Ariane, Ariane-3 with 2-percent profit or something of that ilk, covering Ariane space's cost is in the order of $45 million per flight, and the cost of an Ariane-4 is something like $55 million.

Again, those numbers translate into something like $22 million or $23 million or so per payload, per satellite in the case of the Ariane-3, and then $27 million or so for a larger payload on the Ariane-4. And that says that the current price of $71 million, which will launch a satellite for that $26 million or $27 million that I mentioned, is marginally competitive. If you go significantly higher than that, you won't be.

Mr. NELSON. Thank you, Mr. Beggs.

Mr. Lujan?

Mr. LUJAN. Thank you, Mr. Chairman.

Mr. Beggs, we seem to be always talking about what the pricing should be of the shuttle, and I really don't come to any conclusions from everything that I hear.

I'm concerned because I'm equally a supporter of the work that NASA's doing with the shuttle and, you know, all of the benefits that come from that; equally supportive with that and our commercialization efforts. As a matter of fact, I think that all our research efforts should be directed toward commercialization at some point because that's the way that mankind is going to benefit from it. And there's a real conflict in this whole area of pricing the shuttle.

I'll begin by saying, we just almost lost our entire capability for ELV's—except now, for your agreement with the Air Force, we're back into that—and we have some people out there willing to do it commercially but they're stymied by the fact that they can't do it as reasonably as NASA can. We always have the specter looming over there of the Ariane and therefore, in order to protect ourselves from that "big, bad wolf" over there, we kill our own ELV commercial capabilities.

We went to great lengths to establish the office to facilitate commercial transportation in the Department of Transportation, and we're just stuck there. We say that we want to commercialize, but everything points in the way that we're not going to do it. We had the entire ELV costs; we've already had those. Are we just going to throw them away, except for the few numbers that the Air Force is going to use? What can we do in order to encourage the private ELV companies to succeed? What can NASA do to help them? I'd be very interested in doing that; at the same time, I don't want to wreck the whole NASA program. But I think that it comes down to the bottom line of that. We're either going to kill them or else we're going to find some way of helping them succeed.

Mr. BEGGS. Mr. Lujan, I think we have. We offered the extra hardware, the spare hardware we had, at a discounted price on the Delta, and we would be perfectly willing to do what we can to see the Atlas/Atlas Centaur come into being.

As I mentioned earlier, there's nothing I can do or nothing this country can do about the potential foreign competition that's going to come into this market. The launch vehicle business, for whatever reason, seems to be the 1980's equivalent of the steel mill back in the 1950's, when every country of any size had to have a steel capacity. In these days, it appears that every country who wants to be in the forefront wants to have a launch vehicle capability. You've got the Europeans with the Ariane; you've got the Japanese coming in with the N2-H1 series of vehicles; you've got the People's Republic of China developing—and incidentally, the vehicle that the People's Republic are developing is not at all insignificant technically. It has a cryogenic upper stage, a very, very advanced piece of technology. And you've got the Soviets. And as I said earlier, you've even got the Indians thinking about coming in, so there's a lot of capacity out there.

Now, no matter what you do with the shuttle—I mean, we tend to view the shuttle as a shuttle versus ELV issue. It's not shuttle versus ELV; it's ELV versus all those other ELV's versus shuttle versus anything else, I guess.

I personally believe that there is a market out there for ELV's. The market is in the specialty business, the business that Deke Slayton and his cohorts, David Thompson, is going after in the upper stage business. There's been far more money invested in the upper stage business than in the ELV business, for example, by an order of magnitude. That's going to be a good market, the upper stage business.

Mr. LUJAN. Are you saying, then, that the upper stage is the market that the private sector should concentrate on?

Mr. BEGGS. I think it's the market that the private sector is concentrating on, Mr. Lujan. It's where most of the private money has gone. There's been something like $250 million that has gone into upper stage development privately, whereas, as far as I can ascertain, the total amount of money invested in ELV's privately is maybe a tenth of that, or less.

Now, to get back to your more specific question, what can we do to help them, when we offered the private operators the opportunity to come in, we said we will make it possible for you to launch. We will remove the regulatory restraints, if any—and there were a lot—and we will make available the launch facilities at a very low cost basis, additive cost basis. And we've done that.

Now, the Delta has bid—they haven't won any—but the Delta has bid in a number of those competitive procurements that we've had between ourselves and Ariane. They've been a third competitor in that. And in most of those, they have bid a price below the shuttle, but it's been somewhat higher than the Ariane. In fact, in the testimony before the Special Trade Representative in the 301 case filed by the Delta, when Ariane was asked why they bid the low prices they did on a couple of those procurements, they said to protect themselves against the predatory pricing of the Delta. That's their words, not mine.

In short, they're up against one tough market. The market is not as big as most people anticipated it was going to be at this stage. It is at the low end of the projections that were made by the various studies several years ago; in fact, it's below the low end in some cases. That simply reflects a slowing down, if you will, in the demand curve, plus the making available of a lot of additional telecommunications facilities here on earth, fiber optics, for example. There's an enormous investment going into fiber optics. Transatlantic and Transpacific fiber optic cables are being planned. And those fiber optic cables are very productive.

So, a number of things are happening technically. I happen to think that mankind seems to have an insatiable demand for data and information, so the demand will eventually catch up with the capacity, but right now there's an excess of capacity. You can buy transponders in orbit right now at a very low price, relatively low to what they've been offered. You can even buy a whole satellite, if you want to buy a satellite; they're for sale. And they're unused.

So when you ask what we can do beyond what we've done, I really don't know. We can leave the market, but my view is that if we leave the market, then it will inevitably go abroad. That's my opinion. Now, I realize that NASA's opinion on this is a controversial one; there are folks who will dispute that and say no, it won't, we'll continue to compete favorably. But I look at the pricing in the marketplace and the fact that what we're dealing with here is not just the launch services business. We're dealing here with a very large telecommunications market, and whoever controls the launch services business has got a handhold into the building of the satellites and in building the ground equipment, and that's a very large market, indeed, and it has some other advantages just besides that market alone. If you control the telecommunications business, you have access to a lot of intelligence.

Mr. LUJAN. Let me pursue that business of getting out of the launch market.

How much has been paid to NASA from non-Government agencies for launch services? What's that figure?

Mr. BEGGS. If you go back to the beginning it's about $3 billion in total through now. That goes all the way back, including all the ELV's——

Mr. LUJAN. $3 billion?

Mr. BEGGS [continuing]. All the ELV's that we have sold, and all the shuttle. If you just want——

Mr. LUJAN. No, no, no, no, I'm talking about the shuttle.

Mr. BEGGS. You just want the shuttle itself?

Mr. LUJAN. Yes.

Mr. BEGGS. It's $300 million and growing very quickly to $500 million. Between now and the end of the decade, there's probably another $1 billion or so of potential market out there.

Mr. LUJAN. Is it in the cards, if we really want to help this fledgling industry, that we have so many assigned to the ELV—some kind of an agreement like you made with the Air Force, to help people get going in the ELV business, the commercial ELV business?

Mr. BEGGS. You mean to guarantee them a piece of the market?

Mr. LUJAN. Yes.

Mr. BEGGS. I don't know how. How would I do it?

Mr. LUJAN. Well, assign some payloads to them.

Mr. BEGGS. You mean, just transfer those to them? At current prices, or at higher prices?

Mr. LUJAN. Well, I don't know, but it would seem to me like maybe NASA would have given some thought to that. I think that it's most important that we develop a commercial launch industry, and that the big stumbling block all of the time—you know, we can clear all kinds of regulatory stumbling blocks that they may have; you can let them use the facilities, all of that—but the big log in the middle of the road always is going to be, what's the price that you will charge on the shuttle. And that's the difficult one for them to get around.

Mr. BEGGS. But it has not been the shuttle price, in the last year at least, that has set the level in the marketplace. It's been the Ariane price. They've been below us.

Mr. LUJAN. In all of the——

Mr. BEGGS. They have quoted some at equivalent prices, and a lot below us.

Mr. LUJAN. But isn't the shuttle price——

Mr. BEGGS. And the ones they've won have generally been at prices that are less than those offered by the shuttle.

Mr. LUJAN. So they're competing with Government subsidies, both abroad and here. If it were priced up higher, where Ariane would be slightly below the shuttle, that would still be high enough so that ELV companies could make a profit.

Mr. BEGGS. If you believe the numbers that were put forward by Ariane space as their cost, that I quoted here just a little while ago, that they can launch an Ariane-3 for $45 million, a little less than $45 million, that means that they can sell a PAM-D class payload for $22 million or $22.5 million. Our price for that is $26 million to $27 million. So their costs, by their numbers, are below ours. So they're arguing that they're not subsidizing. Now, I could argue that, and indeed I have, but that's what they're saying that they're willing to price to cost; that's their price to cost. And in my long experience as a businessman, there are two ways to price. You can either price to cost or you can price to market. What they are saying is that if the shuttle raises its price, they'll price to market. If the shuttle doesn't raise its price, then they'll price to cost. They're saying, "Our costs are less than yours; and, therefore, we will be able to undersell, and we're not subsidizing." They've made that flat assertion: "We're not subsidizing; we're just pricing to cost."

Mr. LUJAN. OK. So your argument then is that even if you raise your prices, that Ariane will not?

Mr. BEGGS. I don't know what they will do. They have said that if we raise our prices, they'll raise theirs. In short, they will shift to a price-to-market strategy and price higher. But they will have the capability of pricing somewhat below if they want to, because their costs are lower. So are our costs, as far as that goes. In response to a question that the chairman asked me a few minutes ago, I made the point that the economics of a launch system are very simple. The bulk of the costs are fixed, so the more times you launch the cheaper your cost per flight. And so it behooves you, then, to fly at a high launch rate. It also behooves you to fly at a high launch rate if you're flying a new system like the shuttle in which you're trying to learn more about it because the higher launch rates you fly at, the more you learn. The more you learn the better off you'll be, and the more efficient that you can make that system in the future.

We're flying an R&D system at the present time. This is not something that has been operating for a number of years in which you can anticipate every problem; but the more we fly it, the more problems we can anticipate. Therefore, it behooves us, as a nation, if we want to maintain leadership in the world in launch vehicle technology, the most modern technology we have at present is the shuttle. It behooves us, if we want to maintain that leadership, to fly it as much as we can and to learn as much about it as we can learn about it.

Now, there may be overriding national policy implications which say we want to keep the 25-year-old technology in being and allow it to continue to operate. If that's the case, then you can transfer a certain number per year off the shuttle to them. But I don't know at what price, because the price at that point will be set not by the shuttle, it will be set by the foreign competition.

Mr. LUJAN. It's not an "either/or" situation, either you advance the shuttle or you keep this 30-year-old technology that you're talking about. And I realize my time is almost up, but it seems to me like we need to keep, first of all, that backup capability; and secondly, if we're serious about saying that we really want to commercialize space, we remove whatever barriers we can or lend a helping hand to that industry in order to move ahead. I am not suggesting in the least that we abandon the shuttle and the research that we're doing; I'm very supportive of that also, as you know. I'm just exploring ways of how we can help this industry to move ahead with our stated objective of commercialization of space.

Mr. BEGGS. We believe we're doing that, Mr. Lujan. I don't mean to disparage at all your approach. I yield to no man in my desire to encourage the private sector. But we think we are encouraging the private sector. There is a far larger market in space in the business of materials processing, in the business of expanding further our ability to repair on orbit, in our ability to construct large structures in orbit. We can conceive of antennae farms out there in the future. All of that can be commercial. The potential for commercialization of space is, I think, as broad as the imagination of our entrepreneurs, and that's a broad imagination, indeed. And we're opening that up to them. We're opening it up with the shuttle and we're opening it with the President's initiative on the space station. That will give the opportunity for entrepreneurs, for the first time, to go up and live and work and start to use their imaginations in designing new products and services for sale here on Earth. And that's the commercial market which I think is a multibillion market; some have estimated it as high as $60-odd billion a year that we ought to develop, and we ought to develop that as quickly as possible.

The ELV market, as I say, is both relatively small by comparison with that; and, in addition to that, it's going to be highly competitive around the world. It's like roads and highways and waterways and airways.

Mr. NELSON. Thank you.

Mr. Monson?

Mr. MONSON. When the President directed that you develop a pricing plan for full cost recovery, what was said other than those few words in giving you direction to go?

Mr. BEGGS. That's all.

Mr. MONSON. That was it. How have you interpreted it?

Mr. BEGGS. Well, while arriving at "full cost" seems like it ought to be an exact science, it is far from it. What is meant by "full cost" can range from everything from the full recovery of the total investment that we have made in the shuttle, including all the R&D costs amortized over some mission model, to covering full operational costs.

My interpretation of that and the position that the Agency is taking is that full costs are the full costs of operating the shuttle, including all the spares—that is, the spares usage rate—and the costs of all of the backup replacement equipment we will need in maintaining our manufacturing capability and our other capabilities necessary to operate the system.

Now, you can go from that point, which we said was roughly $83 million in 1982 dollars, 1982 economics, all the way up to a much higher figure. You can also go to a much lower figure. Once you have flown the shuttle, say, 5 or 6 times a year you have paid for almost everything you need to launch at a significantly higher rate. The only additional costs you have to incur at that point are the costs of the expendables, the external tanks, the solid rocket booster propellant that you burn off, and the other consumables plus the costs of operating while you're up there. That cost, in 1982 dollars, is a little less than $33 million a flight. It's about $32.8 million. Again, these are our figures.

And if you want still another price to confuse the issue still further, the in-between or the so-called short run, out-of-pocket costs or the costs that include some of the spares costs and some of the costs of amortizing some of that equipment you're going to have to replace, that's $51.2 million. Again, in 1982 economics. And then you can go all the way up—I dare say some of the subsequent witnesses here will go all the way up to numbers that exceed $100 million.

But my view is that you've got to pick one of those numbers and take a stand, and decide what it'll be. We just happened to pick the $83 million.

Mr. MONSON. Well, if you're going to be operating at least five to six missions yourself a year without any commercial payloads, is there any reason that you should be maintaining, then, commercial payloads, or should you get out of that business completely?

Mr. BEGGS. Well, my view is that we should continue to fly commercial payloads. You can argue whether we should go after the entire market, but the experience that we get in flying those gives us the understanding that we need in order to go on and do the next step. It's my vision that at some point in the next 15 or 20 years, we are going to make our facilities on orbit permanent. That's the whole meaning behind the space station, is that we want to make things permanent. The reason for that is obvious, because the cost of the spacecraft is large; if you can extend its life, you reduce its annual operating costs significantly. So we're going to want to make them permanent. We're going to want, therefore, to visit, revisit, and repair; we're going to want to bring them back and do work on them to update them, modernize them; and the space station gives us that kind of potential.

So being able to launch them on the shuttle enables us to do the kind of mission that we did last fall, and that is to go up and retrieve a couple of errant satellites. It also permits us to start to learn how to repair them on orbit. It also teaches us a little bit of how they operate in orbit—that is, how you check them out and do the other things you're going to need to do. So there's a capability development there that says we ought to stay in that marketplace—at least, if it's going to be cut back, we ought to be in it to some extent in order to learn those various lessons. They are important lessons.

Mr. NELSON. Mr. Smith?

Mr. SMITH. Mr. Beggs, how extensively have you looked into or gone into the so-called two-tiered pricing structure where we charge, say, more to a commercial venture like a satellite, and less to a research project that may not have the same commercial application? Is this feasible? Have we gone anywhere in that area?

Mr. BEGGS. Oh, sure. You could run a many-tiered pricing system. We do, indeed, run a bit of a two-tiered pricing system vis-a-vis the DOD, recognizing the investment that DOD has made in the facilities and services they give us in turn. And we give them a quid pro quo for that and price their price for riding the shuttle at somewhat less than that we charge for commercial flights.

We've looked at various two-tiered and multitiered pricing systems. The problem that you run into is that—I think the commercial satellite people—there are two sides to this equation. There is the commercial satellite guy who is buying the service; he, perforce, wants to buy it as cheaply as he can because he's competing in a highly competitive marketplace. On the other side is the launch service, who would like to charge the highest price they can so as to maximize the return on the launch services. The satellite builder and operator will seek the lowest level, and in any tiered pricing system he will argue with some justification that the cost of integrating a commercial satellite into the shuttle or even onto an ELV is less than integrating a highly complex scientific satellite in the shuttle or on an ELV. So he will argue for equity, with justification, that he ought to be charged a lower price, not a higher price. Once you have—basically all we do with a commercial satellites is we put him on a standard cradle, in a standard cocoon-line arrangement, a shield, and then we take him up into a 28½ degree orbit; we open the shield; we energize the springs, and out he goes. From there on, he's on his own. Whereas for a scientific satellite or a more complex military payload, we require a great deal more integration, special cradles, special integration activities——

Mr. NELSON. Hold right there, Mr. Beggs. If you tiered your pricing system, you would get strong arguments from the commercial folks that they ought to get lower prices, rather than higher prices.

Mr. SMITH. Two points. How do you—which way would you rather go? You see, I've put you on the spot.

Mr. BEGGS. Good Heavens, I've been arguing this issue for over a year now, and I'm getting more confused daily.

Mr. SMITH. Well, I guess seriously what I am concerned about, without the tiered structure it seems like we're hurting the research areas because they obviously cannot be—well, short of the amount of commercial results that you're going to get, obviously, from the satellite——

Mr. BEGGS. On the one hand it takes some effort to do the work with the commercial folks, and you do have to be able to work with them over time. On the other hand, any price that recovers that shortrun marginal cost or incremental cost is a contribution toward the overall operation of the shuttle and thus lowers the cost per flight for our scientific and military satellites. If you go above marginal, obviously, you're recovering that. I fully realize that a lot of Sears, Roebuck suppliers have lost their shirt pricing that way, but I assume that in this case we're going to fly the shuttle; that's the assumption I start with, that we're going to fly the shuttle some number of flights, regardless of whether we serve the commercial market or not. So if we are going to fly that for our scientific and military payloads, then it pays, rather than costs, to fly the commercial satellites if you can price anything above your marginal costs.

Mr. SMITH. Thank you.

Mr. NELSON. Mr. Barton.

Mr. BARTON. Thank you, Mr. Chairman.

I apologize in advance, Mr. Beggs, if I go over some of the ground that's already been gone over. That's the price you pay for a freshman Congressman who comes in and out and is not able to be here all the time. So in a sense, you're going to be my teacher.

What, in your opinion, was the intent of the Commercial Space Launch Act of 1984? Was it to encourage private companies to get into the commercial space launch business? Or was it just to permit them to get into that business?

Mr. BEGGS. Well, that's a hard question. I would answer that it was the latter, to permit them to get in the business if they could make a business out of it.

Mr. BARTON. OK. When NASA was originally organized, what was the intent of that legislation? Was it to put NASA into the commercial launch business, or to encourage scientific research and things that helped our military defense?

Mr. BEGGS. Well, the act specifically enjoins NASA to use the results of its scientific research and its technology development when it sees commercial opportunities to try to assist in exploiting and making them available. And we've done a lot of that over the last 26 years. Indeed, we not only try to pass on the systems-type work, as in communications satellites—that was an entire Government development; it was conceived by both the DOD and NASA that communications satellites would be a large market and a large opportunity, therefore, we spent money putting communications satellites in orbit to demonstrate the technique. And then, when the technique was demonstrated, we came to the Congress and said, "This looks like it's got commercial potential. Why don't you authorize a private company, or quasi-private company, to take it over?" And that's how Comsat was born.

Mr. BARTON. Well, I guess the reason I asked those two questions was, to kind of define the parameters of the debate. We're at a situation here that's not unique to the space industry. We've had it in railroads and telegraph all throughout our history; we've gotten the Government involved in something in the beginning stages, and then when it begins to reach maturity, that there are commercial applications, we go through this transition period. And it's difficult—you know, if you're a free marketeer you want the private industry to have a chance. If you believe this is a realm that Government should only be involved in, then you don't. And of course, it's the—the equation is complicated by the fact that we've got foreign competition that's subsidized by the Europeans.

I'm by no means an expert, but I look at this, and, you know, if we want to give our fledgling commercial industries an opportunity, then naturally we want NASA to price their launches higher. If we don't, if that was not the intent of the act in 1984, then we want you to price your launches lower so that you can compete with the Europeans.

And it's been my experience, in what little experience I've had with the Government, that the Congress is not a very good pricer as it tries to determine what the free market would do if the market was left to itself. So we've got an excellent chairman in Mr. Nelson, and I'm sure we're going to try to do the best we can. But we really need some help; at least I do.

Would you agree that, with the Congressional Budget Office, that we're basically talking about a low cost of $42 million to a full cost of $186 million? Are we in that——

Mr. BEGGS. No, sir; I don't agree with that.

Mr. BARTON. You don't agree with that?

Mr. BEGGS. I just stated where we are at. The marginal cost, as we see it, in a year is $32.8 million in 1982 economics, $33 million, if you will, in 1982 economics. The average full cost over the time period we're discussing, that is the outyears, is $83.3 million. And there are all kinds of costs in between those numbers; and if you want to throw in amortization of facilities and orbiters and other things, then you can run the cost up significantly above the $83.3 million.

I would make one final point, however, that the United States has—I consider myself a free enterpriser; I've been a businessman most of my life—but I recognize there are certain functions that the Government takes on in order to facilitate. Among those are highways, airports, airways, waterways, and many other facilities that we put into space to facilitize the access of private industry. I look upon the space shuttle as a similar facilitizer to allow private enterprise to get into space. Space is a new environment; it offers a lot of very interesting potential for commercial development. And as I said earlier, the entrepreneurs who are investing the most money right now are investing it to take advantage of the environment of space. There's been relatively little money put into ELV's, other than the Government money. Remember, we developed all of the current series of ELV's with Government money. They were developed, they were facilitized—that is, all of the facilities were put in place with Government funds; the launch facilities were built with Government funds; and the current production line, which is operating in various places, more or less, has been run on Government funds.

So in effect, any ELV supplier who comes along has the advantage of that past investment, and it's a very large investment, indeed. My guess is that in current dollars, that's an investment of probably $20 billion, $30 billion, $40 billion. That's a big investment.

Mr. BARTON. Mr. Chairman, could I ask just one final question?

Mr. NELSON. Sure.

Mr. BARTON. I'd like to follow up on what Congressman Walker—an idea that he suggested. Would NASA be at all amenable to some kind of a bid procedure, kind of like a job shop, and let each launch—instead of giving you a specific target, just let you negotiate and get the best price that you could?

Mr. BEGGS. Yes, sir; I think that could make sense. And, indeed, the way this market appears to be going, with the competition that's coming in, it is boiling down to a sealed bid kind of business where the individual or the company that's buying the launch service is asking for a bid against his requirement.

Well, I discussed some of the problems inherent in that, but it is something that I'm sure could be operated, that is, provide a range of pricing, a range of potential prices, and then just submit sealed bids for any particular procurement.

Mr. BARTON. Thank you.

Mr. NELSON. Mr. Slaughter?

Mr. SLAUGHTER. No questions.

Mr. NELSON. OK. Mr. Walker, did you have any further questions?

Mr. WALKER. Just a couple of quick ones, here, to round out the record.

You said that you thought the marginal or additive cost was somewhere around $33 million in 1982 dollars. What's your estimate of the fixed component cost in a launching range of 16 to 24 flights?

Mr. BEGGS. On 16 to 24, the fixed cost would run in the order of $45 to $50 million.

Mr. WALKER. That's over and above the marginal cost?

Mr. BEGGS. Yes.

Mr. WALKER. OK.

A couple of weeks ago Mr. Savoca of TCI stated that NASA had overstated the learning curve cost improvements. Tell me what you think about your assumptions.

Mr. BEGGS. Well, I don't know what he's—I'd have to find out what he's referring to. Actually, we are doing a little better right now on our production learning curves, which are the learning curves that are most important in terms of the average cost per flight. If he's referring to the fact that we have not yet gotten over some of our problems and as a consequence are not on a smooth flight rate, in a smooth flight rate regime, I would concur in that; we certainly aren't. But if you watched us last year, we launched one a month; and that means we were turning those orbiters around better than our learning curve had indicated. Then we ran into the tile problem in December, and that set us back a couple months. But I look on those as things that happen in the first few years of any new kind of system, and we'll overcome them. If we can turn these vehicles around the way we were turning them around last fall, then we'll be able to achieve our flight rate and we'll be able to beat our learning curves, and I believe we will.

We're realizing savings all the time as we learn how to do these things a little better.

Mr. **Walker**. All right. Earlier I had asked you about what you thought the fixed cost to be, and I gave you a range of 16 to 24, and you answered $45 to $50 million per flight. Can you give us a yearly figure in that flight range, fixed cost?

Mr. **Beggs**. Mr. Chairman, I'd like to supply that for the record, if I may. I'm not trying to hedge on this but I think I——

Mr. **Nelson**. OK, that's fine.

[The information follows:]

Based on the STS flight rate supporting the runout of the FY 1986 Budget, 17 flights are planned for FY 1987, increasing to a total of 24 flights per year beginning in FY 1989. The total fixed costs, including Network Support and Research and Program Management (R&PM), associated with achieving the flight rate of 17 in FY 1987, are estimated at approximately $1.2 billion in FY 1982 dollars. The fixed cost estimate for the 24 flights budgeted in FY 1989 is also approximately $1.2 billion in constant FY 1982 dollars. This FY 1989 fixed cost estimate equates to approximately $50 million per flight in FY 1982 dollars.

Mr. **Walker**. What do you think would be the advantage, if any, to NASA, if you adopted a marginal cost pricing for the shuttle?

Mr. **Beggs**. Well, in my view there would be no advantage to adopting a marginal cost pricing system if we did that. We would be covering the fixed cost and the Government would bear the full burden of the fixed cost. There are some advantages to pricing somewhere between marginal costs and full costs because, on a system—anything you can recover, or let's say a significant amount of money per flight, over the marginal cost if you could acquire a larger part of the market would result in a larger contribution to your fixed cost. If you thought that adopting a strategy of pricing somewhere above marginal cost but well below fixed cost would guarantee you the access to the larger share of the market, then I think it would be a good pricing strategy because there are a lot of other advantages for the country.

I mentioned the fact that the pricing strategy that Ariane, I think, has in mind is directed toward capturing not only launch services market but the satellite market, the satellite manufacturing market, and all the technology that that represents, as well as economic advantage to the countries involved, plus the follow-on ground support market, the ground systems market, which is the big part of the market. And we sometimes lose sight of that when we talk about the commercial satellite market, that this country really enjoys a very substantial advantage from being the number one supplier of satellites and ground equipment to the world. We are by far the leaders. As a matter of fact, we were the only ones in it up until a few years ago. And that market, our ability to retain the lion's share of that market is much more important than retaining the lion's share of the launch market or getting our ELV's competitive. It really is a much more serious issue.

The technology that that represents, the leadership position it represents, the position that it puts us in the world in a number of very important telecommunications activities is exceedingly important, and you can't lose sight of that.

Mr. **Nelson**. You've already talked earlier about research and development and that being a cost to the Government. What about the proposals that, within your pricing policy, you ought to include the investment cost in the fleet of the Orbiters?

Mr. **Beggs**. In the Orbiters themselves? Well, you could do that. We didn't favor it simply because we felt that the orbiters were an investment which the country had made primarily for its own purposes. We built the shuttle not for the purpose of launching commercial satellites, although we anticipated from the beginning that we would be launching them, but our prime objective in building the shuttles was to posture ourselves in a position of world leadership, and certainly we have done that with the shuttle, and to launch the very large military and scientific satellites that we intended to launch in the out years.

As you know, Mr. Chairman, the shuttle itself was sized primarily to handle the very large Defense satellites. And, so it was built to a scale, and no doubt cost somewhat more than it would have if we had built a smaller vehicle primarily to launch commercial satellites. Therefore, you might argue that some of the costs should be burdened onto the price for commercial satellites, but certainly not the whole amortization of the shuttle fleet.

Mr. **Nelson**. All right. Now, when Mr. Savoca testified here he said that NASA should include within its fee the following items: interest on the Federal investment in building the orbiter fleet, and the cost that a private firm would have to pay to ensure the orbiter fleet. What's your comment to that?

Mr. **Beggs**. Well, that issue has been raised a number of times. My view on the question of finance costs is that one should attempt, over time, to get enough contribution to where you consider that you've gotten some return from the investment. To my knowledge, we have never tried to burden any of the investments this country has made in various activities, whether it be facilities we've put in for the development of nuclear power or facilities we've developed for transportation. We've never tried to burden that with interest costs.

The other part of that question relates to the equity of burdening the shuttle system with interest costs. We're not suggesting burdening ELV's with interest costs on the investment that's been made in those systems for the production facilities and the launch facilities that are used to launch those.

He would argue, I suppose, "well, the ELV's are not reusable," and that's so; they're not reusable, and therefore, you can't amortize over something that goes up once and burns out and doesn't come back. And, that's true, but that unfortunately is the disadvantage that ELV's suffer over shuttle. One is reusable and one isn't.

Mr. **Nelson**. Any further questions from the committee?

[No response.]

Mr. Beggs, thank you for your patience. I'm sorry we had the interruptions of those three recorded votes, but such is the life here on Capitol Hill.

Mr. **Beggs**. I understand, Mr. Chairman, and thank you.

Mr. **Nelson**. Thank you, and have a nice day.

Would Ms. Dorn please join us now?

Ms. Jennifer Dorn, Director of the Office of Commercial Space Transportation, U.S. Department of Transportation. We are glad to have you.

STATEMENT OF JENNIFER L. DORN, DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION, U.S. DEPARTMENT OF TRANSPORTATION

Ms. DORN. Thank you.

Mr. Chairman, in May 1983, the President announced the basic space launch policy goals for the United States. One of the most important of those goals was to ensure a flexible and robust U.S. launch posture to maintain space transportation leadership. Another was to optimize the management and the operation of the shuttle program, to exploit the unique attributes of the shuttle, and to encourage the development of commercial launch operations by the private sector.

It is clear that the committee's support of these goals has played a pivotal role in providing for the success of the Nation's space program. The Department of Transportation—and Secretary Dole in particular—share your enthusiasm for these commercial endeavors, and I would like to focus my remarks today on three of those particular endeavors: first, supporting increased commercial activity levels in space; second, maximizing of the shuttle program; and third, encouraging a private sector expendable launch vehicle industry.

Witnesses before this committee have linked the success of these initiatives to the Government's policy to recover the full cost of shuttle services and capabilities which are provided to commercial and foreign users. As you know, that is the President's policy, to recover the full costs in the post-1988 period. This was the original intent of the plans for the shuttle pricing, and is consistent with comparable practices across the Government. It is our view that such full cost recovery allows for the effective implementation of all of these U.S. space goals.

We all recognize that private firms now have the wherewithal to explore activities in space that only a few years ago were barely imaginable. Much of that effort is thanks to NASA's and congressional leadership. We expect the space-related investments to grow quickly in future years, creating many new jobs and greater prosperity for all Americans. For this reason, the U.S. Government provides separate incentive pricing, not subject to full cost recovery, as a means of encouraging technology research. And that, we believe, is critical in precommercial activities.

NASA invests significant resources assisting such endeavors. We heartily support those efforts to stimulate the private investment in the commercial use of space through joint endeavor agreements and other provisions of NASA's commercial space policy. We believe that it is in this initiative, in particular, that the partnership of Government and private industry can make essential contributions to the successful commercialization of space.

Consistent, then, with the administration's policy, it makes good economic sense to continue Government assistance designed to encourage such R&D initiatives. This assistance should no longer be provided once these endeavors become commercial. And here we're talking about mature, proven, revenue-producing types of commercial activities, to which the full cost recovery applies.

Business decisions, then, should not be made on the expectation that Government will provide financial support in perpetuity, nor should the taxpayers be expected to support businesses in this manner.

Perhaps more importantly, though, there are good reasons why the Government should not subsidize commercial space projects. First, transportation subsidies will necessarily eat into the basic science and R&D efforts critical to this nation's space leadership. And this, I must admit, is a serious concern, Mr. Chairman. The danger of overtaxing our system to support commercial ventures when R&D space initiatives such as space station and shuttle-unique missions should be the real focus of our attention.

Second, such subsidies will seriously impede the development of private sector launch options, and the question then becomes, will we have the flexible, diverse capability to support these new demands in the years to come?

There is no question that the central element of America's space program is the Government's primary launch system, the shuttle. The most technologically advanced and successful manned launch system available in the world today, the shuttle is vital to our programs for advancing the state of scientific knowledge, pushing the limits of technology, launching interplanetary missions, and developing new industries. It affords new and wholly unique opportunities to do on-orbit experimentation and research, as well as provide a test bed for proving the commercial viability of manufacturing materials in space. It also serves important military requirements, and will play a fundamental role in the construction and servicing of the space station. Its unique capabilities form the foundation of U.S. leadership in space. Full cost recovery for commercial and foreign users will not detract in any way from the pivotal role of the shuttle program in U.S. space policy. Rather, full cost pricing, in keeping with time-honored principles of sound program management, will serve to establish an enduring basis for the full exploitation of the shuttle's special capabilities, with the assurance of price stability and predictability for future customers, which is extremely important.

Mr. Chairman, as space becomes an ever more attractive setting for creative enterprise, our space transportation options must expand to fulfill increasing customer demand. And we are finding, as evidenced by the receptivity to the Ariane capability, that customers do, in fact, wish for alternatives. They are not willing to rely exclusively on a single system.

As noted in his decision to encourage the development of a private sector ELV industry, the President recognized that such an alternative in particular would add to the general economic vitality of the United States and provide the United States with a more robust space launch capability.

In keeping with that goal, and in response to direction by both the President and the Congress, the Department of Transportation has been directed to create an environment in which a viable, responsive, and innovative domestic ELV industry can develop. We are not assigned to guarantee its success, but merely to ensure that an environment is created that does not create unfair competition.

Sometimes I think we forget that expendable launch vehicles indeed represent a national asset. They are important as a means of providing assured access to space and as an important complement to the shuttle launch capability. They are, in fact, a hedge against unanticipated increases in demand or limitations in shuttle capacity, at no direct cost to the taxpayer.

It is clear that the commercial launch industry cannot become viable unless full cost recovery is established for the shuttle. Our goal is not to set an artificially high price for the shuttle, or to preclude the shuttle from competing for foreign and commercial payloads. We seek full cost recovery pricing based on standard Government practice to provide full reimbursement for services rendered to foreign and commercial customers. When the Government sets prices for services which it offers in competition with the private sector, it is even more important that full costs are recovered so as not to distort the true utility to the market of these services.

I would note here also, Mr. Chairman, that the administration has not yet reached a decision as to the appropriate level for post-1988 pricing that would reflect full cost recovery. We are in the process of doing so.

We believe that commercial and foreign demand for launch services provides ample opportunity for the shuttle, a domestic commercial ELV industry, and Ariane to compete in the marketplace. In fact, it is likely that shuttle-unique needs will expand, particularly with the demands placed on the shuttle program by such things as the space station, national security, and those emerging commercial manufacturing endeavors. When this occurs, the shuttle capacity in the out years may well be inadequate at any price to handle the needs of those commercial and foreign customers whose activities do not require manned missions. Without a private sector launch capability to provide for such contingencies, we stand to lose even greater ground to foreign competition, or we risk bumping important research and development missions to cover far less important commercial and foreign payload missions which don't require the manned capabilities of the shuttle.

If a full cost recovery shuttle price is not implemented, this private sector transportation option simply will not develop. The impact of such a decision will be felt in decades to come as new developments and demands make it clear that an ELV industrial base would continue to be an important national asset which complements the capabilities of the shuttle.

I am convinced, Mr. Chairman, that together the private sector and the Government can work to maintain this Nation's leadership in space by providing a full spectrum of launch services to meet the diverse requirements of an expanding market. This committee will play an important role in determining the national strategies by which we meet this challenge. We certainly look forward to working with you in an effort to ensure the success of each of the Nation's goals in the space program, and to bring to fruition the promise that a space-based economy holds.

Thank you, Mr. Chairman.

[The prepared statement of Ms. Dorn follows:]

Testimony of

JENNIFER L. DORN
Director, Office of Commercial Space Transportation
Department of Transportation

before the

Subcommittee on Space Science and Applications
U.S. House of Representatives

March 5, 1985

In May of 1983, the President announced basic space launch policy goals for the United States. Those goals were to ensure a flexible and robust U.S. launch posture to maintain space transportation leadership, to optimize the management and operation of the Shuttle program, to exploit the unique attributes of the Shuttle, and to encourage the development of commercial launch operations by the private sector of the United States.

This Committee's support of these goals has played an important part in providing for the success of the Nation's space program. As you know, the Department of Transportation, and Secretary Dole in particular, share your enthusiasm for these commercial space initiatives. Today, in my testimony, I would like to focus on three of those: supporting increased commercial activities in space; maximizing the benefits inherent in the Shuttle program; and encouraging a private sector expendable launch vehicle (ELV) industry. The success of these initiatives has been linked to the Government's policy to recover the full cost of Shuttle services and capabilities provided to commercial and foreign users. As you know, the President has directed that the Shuttle recover full costs of services provided to foreign and commercial customers. This was the original intent of the initial plans for Shuttle pricing and would be consistent with comparable practices across the Government. It is our view that such full cost recovery allows for the effective implementation of U.S. space goals.

Commercial Use of Space

It is well recognized that private firms now have the wherewithal to explore activities in space, that only a few years ago were barely imaginable. We expect space-related investments to grow quickly in future years, creating many new jobs and greater prosperity for all Americans. Space-based technology research is critical to such endeavors. For this reason, the U.S. Government provides separate incentive pricing, not subject to full cost recovery, as a means of encouraging such technology research.

NASA invests significant resources in support of such endeavors. We heartily support NASA's efforts to stimulate and support private investment in the commercial use of space--through Joint Endeavor Agreements and other provisions of NASA's Commercial Space Policy. We believe that it is in this initiative, in particular, that the partnership of government and private industry can make essential contributions to the successful commercialization of space.

Consistent with the Administration's policy, it makes good economic sense to continue Government assistance designed to encourage R&D initiatives. This assistance should no longer be provided once these endeavors become commercial. Business decisions should not be made on the expectation that Government will provide financial support indefinitely, nor should the taxpayers be expected to support businesses in this manner.

Perhaps more importantly, there are good reasons why the Government should not subsidize commercial space projects: First, transportation subsidies will necessarily eat into the basic science and R&D efforts critical to this Nation's leadership in space. Secondly, such subsidies will seriously impede the development of private sector launch options and the availability of the flexible and robust launch capability upon which an aggressive space program must be founded.

The Shuttle Program

Perhaps the central element of America's space program is the Government's primary launch system, the Shuttle. The most technologically advanced and successful manned launch system available in the world today, the Shuttle is vital to our programs for advancing the state of scientific knowledge, pushing the limits of technology, launching interplanetary missions, and developing new industries. It affords new and wholly unique opportunities to do on-orbit experimentation and research, as well as provide a test-bed for proving the commercial viability of manufacturing materials in space. It serves important military requirements and will play a fundamental role in the construction and servicing of the space station. Its unique capabilities form the foundation of United States leadership in space. Full cost recovery for commercial and foreign users will not detract in any way from the pivotal role of the Shuttle program in U.S. space policy. Rather, full cost pricing, in keeping with time-honored principles of sound program management, will serve to establish an enduring basis for the full exploitation of the Shuttle's special capabilities, with the assurance of price stability and predictability for future customers.

Commercial ELVs

As space becomes an ever more attractive setting for creative enterprise, our space transportation options must expand to fulfill increasing customer demand. As noted in his decision to encourage the development of a private sector ELV industry, the President recognized that, such an alternative, in particular, would "add to the general economic vitality of the United States and provide the United States with a more robust space launch capability."

In keeping with that goal and in response to direction by both the President and the Congress, the Department of Transportation has been directed to create an environment in which a viable responsive, and innovative domestic ELV industry can develop.

It is clear that expendable launch vehicles represent a national asset whose production lines and operational facilities should be maintained. They are essential as a means of providing assured access to space and as an important complement to the Shuttle launch capability. They are an essential hedge against unanticipated increases in demand or limitations in Shuttle capacity, at no direct cost to the taxpayer.

The commercial launch industry cannot become viable unless full cost recovery is established for the Shuttle. Our goal is not to set an artificially high Shuttle price or to preclude the Shuttle from competing for foreign and commercial payloads. We seek full cost recovery pricing based on standard government practice to provide full reimbursement for services rendered to foreign and commercial customers. When the Government sets prices for services which it offers in competition with the private sector, however, extra care must be taken to ensure that full costs are recovered so as not to distort the true utility to the market of these services. The Administration has not yet reached a decision as to the appropriate level for post-1988 pricing, nor has it identified the range of prices that would reflect full cost recovery.

We believe that commercial and foreign demand for launch services provides ample opportunity for the Shuttle, a domestic commercial ELV industry and Ariane to compete in the marketplace. In addition, there is a real possibility that Government and Shuttle-unique needs will expand--particularly with the demands placed on the Shuttle program by the space station, national security, and emerging commercial manufacturing. If this occurs, Shuttle capacity will be inadequate--at any price--to handle the needs of those commercial and foreign customers whose activities do not require manned missions. Without a private sector launch capability to provide for such contingencies, we stand to lose even greater ground to foreign competition. If a full cost recovery Shuttle price is not implemented, this private sector transportation option will simply not develop. The impact of such a decision will be felt in decades to come as new developments and demands make it clear that an ELV industrial base would be an important national asset.

Together, the private sector and the Government can work to maintain this Nation's leadership in space by providing a full spectrum of launch services to meet the diverse requirements of an expanding market. This Committee will play an important role in determining the national strategies by which we meet this challenge. We look forward to working with you in an effort to ensure the success of each of the Nation's goals in the space program and to bring to fruition the promise that a space-based economy holds.

Mr. NELSON. And we thank you. And again, thank you for your patience; I apologize for the interruptions, but there's nothing we can do about it.

Ms. DORN. Absolutely. I understand.

Mr. NELSON. Ms. Dorn, what cost items do you think should be included in calculating the launch fees for the shuttle?

Ms. DORN. As you know, Mr. Chairman, there are a number of definitions floating around as to what would be appropriate to include or not include in a full cost recovery price. That discussion is currently being undertaken within the administration, and I would make a comment with respect to some of the cost elements that have been in previous pricing policies or the original pricing policy which are legitimate elements which should be considered. One of those which, again, appeared in the original pricing policy, was depreciation of the orbiter and facilities. Realistic assumptions about flight rate have a great deal to do with what is a full cost recovery price. Those kinds of elements, as well as a number of others, are currently being discussed in the context of interagency groups, and I think the importance of this policy is to understand that, again, we do not seek to find an artificial price in which the private sector can compete, but rather to use the standard Government definition that would incorporate those kinds of costs that would be full reimbursement to the Government for the services it provides for commercial and foreign payloads.

Mr. NELSON. All right. Now, I didn't understand you. Did that include recoupment of investment in the orbiters?

Ms. DORN. With respect to the sunk research and development, which is already gone——

Mr. NELSON. You're saying to include that or not?

Ms. DORN. No, not to include that.

Mr. NELSON. Not to include it.

Ms. DORN. As a matter of fact, I do not believe that that is the subject of any debate within the administration; that is a given, that the sunk R&D is something that the Government has already expended; it should not be the role of the commercial sector to reimburse——

Mr. NELSON. OK. Now, what's your opinion about the investment in the fleet of orbiters, aside from the R&D?

Ms. DORN. In terms of depreciation costs, I think that that well may be an element that should be legitimately considered. As I mentioned, in the original pricing policy that the shuttle issued for the 1983 to 1985 time period, depreciation of the orbiter and the facilities was a part of the full cost recovery policy, as well as the issue of it being priced to recover the costs over a 12-year period. And since that time, we have changed that. That may well be another legitimate cost to be considered. I am neither advocating or not advocating; I think it would be premature to do so.

Mr. NELSON. Would you include interest in that depreciation schedule?

Ms. DORN. That is another element that has been mentioned. It is my understanding that interest was not included in the original pricing policy. What is being looked at, Mr. Chairman, is the method by which the Government recovers full costs for other types of services across the Government, and that will be the standard by which a recommendation will be made to the President.

Mr. NELSON. But I'm trying to get your opinion here.

Ms. DORN. I know you are. [Laughter.]

Mr. NELSON. I know all of these things; we've laid them out. So, you know, if you've got an opinion one way or another, that's what we want to know. All these things are on the table; they've been on the table through all of these hearings. A couple of weeks ago, for instance, Mr. Savoca had testified that he can't be competitive with the space shuttle unless the fee is $150 million per dedicated flight.

Let me ask you this opinion. Do you think at that kind of price, that U.S. ELV's could be competitive with Ariane?

Ms. DORN. I believe that the United States can retain its competitive position at a full cost recovery price. It's clear that the customer wants alternatives and it's clear that domestic ELV's can provide the kind of flexibility that the Government can't provide in terms of financing and insurance. Arianespace, in our view, through the deliberations that we've participated in with respect to section 301 as well as our personal discussions with ESA and our analysis in an interagency group, indicate clearly that in our view, Arianespace cannot capture the entirety of the market, and it has no desire to do so because it does not make good economic sense to do so.

I would like to point out that at whatever price is recommended, it is not related to the price that the industry says they can be competitive. Our business, our assignment from the Congress and from the President, was to encourage the creation of an environment in which they could compete, and assigning legitimate, full cost kinds of prices is the only way in which a private sector can compete. If they can't at that point, then perhaps they should not be in the market. I don't think that places a great deal of risk to this Government vis-a-vis the Ariane because of the long leadtime, and I think that's an important point that we would wish to make.

If, in fact, we'd determine that we are wrong and that Arianespace in fact would choose to change its policy and recover a greater and greater portion of the market, we're going to notice that. The long leadtimes that are required and our analysis of their budget and the kinds of significant investments they would have to make in order to get that capacity up to capture the market is something that we're going to notice. And if, in fact, that happens, then the Government is flexible enough to change the shuttle pricing policy. I don't think we're going to run into that problem.

Mr. Nelson. You said that Ariane would not usurp the total market. You made that statement?

Ms. Dorn. Yes.

Mr. Nelson. Why?

Ms. Dorn. I believe that—first of all, customers want diversification, and that's become very clear. And it's unlikely that the customers themselves would allow any one launch vehicle supplier to capture the entirety of the market. The risk is too great. Second of all, it is our understanding that now, the Arianespace launches approximately—or will launch through 1989, I believe it is—8 launches per year, and in the 1990 timeframe, approximately 10 per year. Beyond that, our analysis shows that it would require significant investment. First of all, the ESA member countries have little desire to expand the market. They have other competitive investments which they wish to make in their cooperation in the international—the space station and HERMES, research on the cryogenic engine, just to mention a few—and in their recent meetings, as I am sure you will discuss with the ESA participants on Thursday, they made a decision to increase their budget. So they have other irons in the fire.

Second of all, there is little economic justification to make those increased investments. The demand out there is not big enough to justify the significant investments that they would have to make.

Mr. Nelson. All right. You made reference to an analysis that you had made, and you quoted from that analysis. Will you furnish this committee a copy of that analysis?

Ms. Dorn. We'd be happy to provide whatever we can to the record. As I had mentioned, some of this analysis is based on views from the intelligence community, others from our section 301 participations, and still others from the interagency group, and we'd be happy to provide whatever information we are able to with respect to that.

Mr. Nelson. Without objection, that will be inserted in the record.

Now, based on what you just said, you heard Mr. Beggs testify earlier that it was his belief that only $50 million to $75 million investment is required by Arianespace to expand.

Ms. Dorn. Uh huh. Okay.

Mr. Nelson. Why do you have—can you help me reconcile what are the differences there?

Ms. Dorn. I will try to, Mr. Chairman.

I couldn't comment on the specific number with respect to the $50 million to $75 million; however, I would like to speak in qualitative terms about our analysis with respect to the increased investment required to capture beyond the market that Arianespace has already captured.

One significant investment which would have to be made would be an increase in the production capacity. And a limiting factor there which would not be a limiting factor in customary operations in the United States would be that with the 11 countries who serve, in fact, as suppliers or subcontractors, Arianespace has an agreement—or ESA has made an agreement, actually—that any contracts that are awarded for increasing capacity must be on a pro rata share or proportionate to the contributions that the ESA member countries make to ESA itself. You can imagine the financial straitjacket that that could place Arianespace in if they needed to increase their capacity.

Payload processing and integration, propellant storage facilities—it is our clear understanding that these facilities would also need to be upgraded.

Additionally, it is clear that the first pad, the ELA-1, which ESA has indicated to us that they will decommission—and it is my understanding that there is some disagreement with respect to that—but outside of the disagreement, the ELA-1 is not equipped at this point to accommodate the Ariane-4. It would require significant investments to upgrade that so that it could accommodate Ariane-4, which, as you know, it's the French desire that they move more and more to that more capable vehicle.

Mr. Nelson. So you are saying then that you don't put a figure to it, but you're saying that you think it's considerably more than $50 million to $75 million in order for them to expand?

Ms. Dorn. Yes.

Mr. Nelson. All right. Now, let me go back to my initial question, and let me make sure that I understand it. Did you say yes or no that, on the basis of $150 million per flight—which is what Mr. Savoca said that he would have to have in order to be competitive—did you say yes or no, that U.S. ELV's at that equivalent flight rate could be competitive with Ariane?

Ms. Dorn. If the industry indicates that they could be competitive at that price, I would imagine they are right.

Mr. Nelson. Well, that's what he said.

Ms. Dorn. Right. That does not have anything to do with our decision in terms of what full cost recovery is. We're not seeking to find an artificially high price, just as we're not seeking to have an artificially low price. That merely distorts the market. And as I had mentioned in my testimony, the administration is in the process of determining just what that standard definition would be.

Mr. Nelson. All right.

Before I turn over to my colleague, let me just make sure that I understood.

You said that from your standpoint, the pricing ought not to include research and development?

Ms. Dorn. That is correct.

Mr. Nelson. Did you say yes or no, that it ought to include interest on the Federal investment in building the orbiters?

Ms. Dorn. Mr. Chairman, I indicated that that is, indeed, a legitimate cost element to be considered——

Mr. **Nelson**. Considered? OK, and you didn't take——

Ms. **Dorn** [continuing]. And I did not take a position on that.

Mr. **Nelson**. OK. You didn't take a position on that, nor did you take a position on whether or not it ought to be the Government's investment in the fleet of orbiters.

Ms. **Dorn**. If you mean depreciation, that's true.

Mr. **Nelson**. All right.

You said yes, depreciate, or that ought to be considered?

Ms. **Dorn**. That ought to be considered.

Mr. **Nelson**. OK. Now, what about insurance?

Ms. **Dorn**. I would say that the same holds true, in terms of its consideration.

Mr. **Nelson**. OK.

Mr. Walker?

Mr. **Walker**. Thank you, Mr. Chairman.

Let me get your reaction to the potential for a flexible pricing system that would give us probably a range of prices—not a two-tiered pricing system, but a flexible system—that would operate within the parameters of an absolute low cost of the low marginal cost, and a high cost of, say, the full cost less development. You know that there would be great flexibility within that, with NASA actually even bidding for payloads within the context of that kind of a policy format. What do you see as the problems with that?

Ms. **Dorn**. Well, for commercial payloads, it is not specific as to the full cost recovery price. The industry doesn't know if they're being unfairly competed with or if they have a fair opportunity to compete in the market. That uncertainty is just the kind of thing that we have to get rid of; that's my concern. If you were to take an absolute and say that one point of the range, which reflects full cost recovery, would be for commercial and foreign flights, and there would be another part of the range which would be, in effect, more flexible for noncommercial and nonforeign flights, that would not at all disturb the ability of the private sector ELV industry to compete. But unless you provide that kind of certainty about what the Government's intent is, it is very difficult to make an effective business decision about whether to enter the market.

Mr. **Walker**. Wouldn't you agree that, for those things where there is a viable commercial market, the kinds of things that you point out in your testimony that are fully commercialized at the present time, that there would be a great deal of pressure, for instance, from OMB for NASA to come in at the top range there so that we made the maximum amount of money on it? That that would certainly be something that OMB would be encouraging, that there would be a lot of pressure within the Government? But I would say to you that most businesses that I know in my district that go into competitive bidding, one of the risks in competitive bidding is you don't know what the other side's price is going to be. I mean, they in fact do not have a set price—that if we're going to have some kind of system of that kind, you can't very well say, "Well, the Government price is always going to be fixed," and then everybody else can bid around that. That doesn't get us by the problem of Ariane always knowing what our fixed cost is going to be, and the industry. But the industry should be assured that, for the most part, where there are real commercial loads that are being bid on, that NASA is going to be in the higher ranges of that policy simply because the forces within Government would dictate that. Plus the fact that we're going to have something to say in that. If NASA isn't making the kind of money that we think they ought to make on commercial vehicles, we're going to have something to say in that. The appropriations committees are going to have something to say in that. As a matter of national policy, in fact, there is going to be a good deal to say in why they are not recovering costs in those areas.

Ms. **Dorn**. Congressman, I would just point out that the private sector has no option, really, but to recover its full costs at a certain point within a business planning period. And if they are assured that the Government is not subject to that same type of requirement, where full costs will be recouped for the Government service it provides, that's an unfair situation in which no business effort could really effectively compete.

Mr. **Walker**. Yes, but the fact is that already, as I understand it, some of the ELV competition from the private sector has tried lowball figures in——

Ms. **Dorn**. But at some point in time, they're going to need to recover those costs.

Mr. **Walker**. Sure, and the same thing is true of Government. I mean, if you're going to put NASA into a competitive bidding process and suggest parameters within it, then you've got to give them some flexibility for those determinations. But the point being that I think that there's a time when we're going to arrive in the market and I think that's suggested in your testimony as well, that the fact is that many people out there are going to have no alternative but to go in ELV's. The market is going to begin to set the price out there because there is not going to be sufficient room aboard the shuttle. There are not going to be sufficient other kinds of vehicles available to them, and the ELV people are really going to be in the driver's seat at some point because there will be a market for those launch services.

Ms. **Dorn**. But I'm desperately afraid that those ELV drivers will not have a car, and that is the problem. Because——

Mr. **Walker**. Well, there are some people that may be true of that are in the marketplace right now. Now, the point is, do we put everything else aside and say, protect that segment of the industry until that point when we get there, or are we saying that you are going to set up a policy that in fact allows everybody development within what is really a potential competitive price at some point, right now or in the future? And it seems to me that becomes a much fairer structure then, and that we can't expect Government to set aside a segment of the marketplace or anything of that kind——

Ms. **Dorn**. And the industry is not asking for that. They're asking for a fair opportunity to compete, and full cost recovery would guarantee them that opportunity to compete on a fair basis.

Mr. **Walker**. Well, I'm suggesting that one of the options, though, in that policy would in fact be a full cost recovery, and that NASA would be under a lot of pressure to make certain that in certain—where the flights were in real competition with ELV's—let's face it, that's communications satellites at this point.

That's the segment of the business we're talking about, is launching communications satellites.

Ms. DORN. Correct.

Mr. WALKER. Now, if NASA came in here and showed us that they were flying communications satellites at something less than full cost, they would have an awful lot of explaining to do. They'd have an awful lot of explaining to do to OMB, they'd have an awful lot of explaining to do to this subcommittee, they'd have a lot of explaining to do down at the Appropriations Committee. Because the fact is, that is what we would expect of them. On the other hand, an electrophoresis experiment that has great commercial viability, I might not want to set a price of $105 million for flying that particular mission because, at this point, no one's going to pay that kind of money to fly an electrophoresis experiment.

Ms. DORN. Absolutely.

Mr. WALKER. So if we set a price, if we set one price of, let's say, what that full cost recovery is of $106 million, what we're doing is canceling out a whole series of electrophoresis experiments or electrophoresis concepts that might otherwise fly. And I would prefer to have NASA be able to have the flexibility at that point to say, OK, on that particular mission, because we think that there's a long-term payoff involved, that we'll recover our money later on downstream, that we're going to lowball that figure and we're going to come in at low marginal costs on that. We're going to go $42 million on flying that particular mission.

Ms. DORN. Yes, sir; Congressman, I'd like to say that NASA right now has the option and is exercising the option to have a two-tiered pricing system, commercial and foreign payloads. Only the telecommunications industry, primarily, are the only ones subject to full cost recovery. The commercialization policy as now being implemented by NASA allows those free flights for those things that are high risk, not yet proven, and that opportunity is clearly there.

What we are saying is that if you provide a subsidized transportation to every commercial venture, you are encouraging then a less than marginal business. And in fact, what—and all I'm saying, Congressman—is that right now NASA has that option and is exercising that option with the joint endeavor agreements and those types of things that allow a free flight or a series of free flights until an activity is proven to be commercially viable.

Mr. WALKER. But our job here is to set a pricing policy. And it's going to be a policy that drives us well into a time when there are going to be massive changes. We're looking at massive economic and technological changes that are going to take place in the next 10 years, absolutely staggering changes. Now, if we don't have some kind of a flexible system to respond——

Ms. DORN. Which we do.

Mr. WALKER [continuing]. To those kinds of changes, we're going to be in deep trouble. And to set an artificial price that might end up being too high, or might even end up being too low at the present time, it seems to me it just has some real problems connected with it. And what I'm trying to find out is where, in fact, we have those problems.

What happens if we decide that we're going to have a single pricing mechanism?

Ms. **Dorn**. For commercial and foreign payloads, correct?

Mr. **Walker**. Yes.

Ms. **Dorn**. Then electrophoresis and those initiatives that have not yet proven themselves as commercial ventures are not subject to that policy. A great deal of flexibility is afforded by Congress' and the administration's support for new ventures in space.

Mr. **Walker**. Some of them may well be, however, in the very near future; some of them—you know, there's going to be a fine line walked on a lot of these in the very near future, and we're going to have to have some sort of a bidding process out there, it seems to me, in order to make some of these decisions.

If Government attempts to micromanage this entire process, it would be a little like deciding in 1810 that we were going to micromanage out of Washington the whole development of the West. It just isn't going to work. And so, it seems to me that the very least that we ought to do is set up something that allows a lot of competitiveness, a lot of bidding, and sets a variety of prices. And some of those prices, it seems to me, that in fact the ELV industry is going to be able to compete with; some of those prices they're not going to be able to compete with because, in all honesty, they don't have the capabilities to do the kinds of things that are going to be commercial payloads in the future.

Ms. **Dorn**. I guess that my personal point would be that if we choose to subsidize a particular venture in space because we think it has some national good or national worth, then we should give Government support beyond the JEAs, because those are a given, on a case-by-case basis. But to subsidize the transportation of such and thus squeeze out a legitimate and important venture in space transportation is not to the benefit of new space businesses, and eventually it's going to squeeze out the whole commercialization ventures because we place an excessive concentration on capturing an already commercial venture that does not require a manned presence in space.

Mr. **Walker**. Well, I don't know. I think we're talking around each other here somehow. But you know, because—I guess the question is, if that price then is, as the testimony the chairman cited, at $150 million, and we set $150 million, I guarantee you we are going to lose one whale of a lot of commercial payloads that are not necessarily communications payloads but are other kinds of payloads. You know, if we set that price at $150 million, if that ends up being the realistic price, I think we have set back commercial space development, utilizing shuttle or any other vehicle, by 10 years or more.

Ms. **Dorn**. Certainly, Congressman. But if we set a price that is at the full cost recovery——

Mr. **Walker**. Even if that turns out to be $150 million?

Ms. **Dorn** [continuing]. I do not believe that the United States will lose its competitive position. Certainly, with three viable ventures in the marketplace, the shuttle may well lose payloads, commercial payloads. But they're talking, even in the most optimistic of terms, 24 flights a year. NASA estimates that between two and four commercial flights would be used by the shuttle. So we're talking about a relatively insignificant portion of the shuttle market.

Mr. **Walker**. But I'm saying to you, what if that price turns out to be $150 million? You will admit to me that at $150 million there are not going to be many new commercial ventures flying into space.

Ms. **Dorn**. We have not made an analysis of what a particular price would yield.

Mr. **Walker**. We're citing the analysis that was made before this committee. One analysis before this committee suggests that price is $150 million. I'm not asking you to make a judgment as to whether that $150 million is a correct price, but let's say that is a correct price. At that price, you've got to admit to me that we would set back an awful lot of commercial development that is otherwise going to take place in the next few years, that there aren't very many people that are going to fly at $150 million aboard the shuttle. I mean, do you know anybody who's going to fly at $150 million aboard the shuttle? Do you know anybody that's not going to go to Ariane at $150 million?

Ms. **Dorn**. That is not the basis on which the decision is being made. The basis on which the decision is being made allows the United States to retain its competitive position and allows us to guard against the uncertainty of the increase in demands in the market, and so, for us to be able to have an industrial base.

Mr. **Walker**. My guess is that at $150 million, we're going to have a lot of shuttles sitting on the runway a lot of the time.

Ms. **Dorn**. OK. I'm not sure about your continued reference to $150 million because I don't know that is in any way indicative of any range that the Government is talking about. We have not identified a range.

Mr. **Walker**. I'm not worried about the Government. I'm simply saying that's one analysis we have before the committee. I happen to have some questions about the analysis myself, but that's an analysis by at least one commercial vendor, who then told us that that is the range in which they could survive in the marketplace. But they came forth with a fairly sophisticated analysis that suggested that's the price that the shuttle ought to be charging, that that's real full cost.

Now, if that is in fact the cost, wouldn't you agree with me that we would have real problems selling loads aboard the shuttle at that price?

Ms. **Dorn**. We have not done an analysis of the impact of a particular figure, as in $150 million.

Mr. **Walker**. OK. Well, I'm told here that—MCDAC said that they started with 12 projects. One dropped out—now, this is an electrophoresis project—at $71 million, they still have six projects. If it goes over $100 million, there will be one. Out of 12 projects, they'll be able to fly one if it goes over $100 million. That tells me that we lose a large segment of everything we're counting on for the commercial marketplace for the future if that comes in. And at $150 million, I doubt we'd have the one.

Ms. **Dorn**. Congressman, it seems to me though that some natural selectivity for the use of a national resource like the shuttle should be made, and it seems to me that a good business plan would not incorporate the concept that the U.S. Government will subsidize in perpetuity the transportation costs. Full cost recovery has been known to all of us for a number of years, and that was the intent of the Government. If we were to allow low-cost, subsidized transportation for every venture that wanted to go on the shuttle forever, what happens to other kinds of important research and development missions and other important efforts of the Government, and the space station, those types of things? We have a scarce national resource here. There has to be some type of selectivity, and the whole concept—if some of those projects that McDonnell-Douglas has decided to select or not select, we determine as a government that they're worthy of additional support—some type of additional subsidy beyond the joint endeavor agreements—we should make a decision on a case-by-case basis that, yes, we want to do so. But not grant a subsidy for transportation, which makes no value judgment at all.

Mr. Walker. Well, that's exactly—now you've just come back to exactly what I was talking about in flexible policy. If you had a flexible pricing policy, you could in fact make a case-by-case judgment. If you in fact had the high range——

Ms. Dorn. I would agree with you totally if you talked about the fully commercial ventures on one precise point. Yes, they will absorb the full cost that the Government, in fact, incurs as a result of flying the commercials. And anywhere else along the range you want to have flexibility that is less than commercial. You know, personally, I would be very supportive of that. And I think that the commercialization policy which NASA has issued has gone a long way in that direction.

Mr. Walker. Well, all right. I yield back my time. Thank you, Mr. Chairman.

Mr. Nelson. All right. If the gentleman will yield, before I call on Mr. Smith, let me just—Bob, can you stay here one second while I—I wanted to follow up your line of questioning here and I will just take a minute, Mr. Smith, and I'll get right to you.

But while we're on this subject, I want you to understand, Ms. Dorn, that we are questioning you from the basis of the testimony that has come before this panel.

Ms. Dorn. Absolutely.

Mr. Nelson. And part of the testimony that we've had is that there is this huge commercial market out there in the future in which industries have invested millions of dollars already, hundreds of millions, in communications satellite manufacture and upper stage industry, in the range of $200 million already invested; platforms in the range of $7 million; materials processing in the range of $10 million, and the ELV industry in the range of less than $10 million.

Now, I think it's the responsibility of this panel that when you have private enterprise investing all of that in the future, it is the responsibility for us to determine whether or not, when that private enterprise comes and sits at that table and tells us that you're going to drive us out of business if you put that—if you ratchet that shuttle pricing policy, it's the responsibility of this panel on behalf of the United States to determine what is and what is not true. And is that true? And what Mr. Walker cited to you was the testimony of McDonnell Douglas with regard to their electrophoresis. And they say, you know, "the higher you go, the less economically we're going to be able to compete by going on that mode of transportation." Now, that's the thrust of what we're trying to get. And it's a difficult area.

Mr. **WALKER**. May I make one final point?

I'd just tell you that I don't think that Secretary Dole would want me to vote on Conrail on the basis of full cost recovery.

Ms. **DORN**. Oh, I would have to disagree with that.

Mr. **WALKER**. Well, I happen to think that probably the Conrail situation merits my vote for other reasons. But the fact is that if you take a look at the assets of Conrail and suggest that $1.2 billion pays the full cost of all those assets, I think that there is some question about that. There are some liabilities that are assumed there as well, but I do think that there would be some question involved that there is a true full cost recovery with regard to the Conrail system at the present time, or that we have operated Amtrak for the last several years on a full cost recovery basis.

Ms. **DORN**. I would certainly respect your views on that, Congressman. I would point out that that's precisely the difficulty of getting out of the subsidy business, and that's why this administration has been advocating that and precisely why we're trying to sell Conrail.

Mr. **WALKER**. Sure, and the reason why I think at some point, as I've suggested before, that what we want to do is look at selling off the shuttle, that the best way to prevent that, to resolve some of these problems, is ultimately to sell off the shuttle. And I think we need to begin exploring that very, very rapidly.

Meantime, though, it seems to me that we've got to develop a policy enough to deal with the future.

Thank you, Mr. Chairman.

Ms. **DORN**. Mr. Chairman, if I could—pardon me, could I just interrupt for 1 second?

Mr. **NELSON**. Sure.

Ms. **DORN**. I'll comment on what you mentioned.

I certainly can appreciate the role and the responsibility of this committee with respect to charges and countercharges about the impact of various policies in the space area. I would just like to make a couple of points.

First of all, if Secretary Dole believed this were a win/lose situation—in other words, that we were in some way compromising the commercialization initiatives outside of the ELVs on behalf of simply saving or protecting an industry that we admittedly believe is important—she would be the first one to bring that to the highest levels of the White House and to the President.

Second of all, I think it's really important to understand that some of this investment with respect to upper stages, et cetera, is certainly subject to the market forces themselves. It is interesting to note, particulary in light of the upper stage type of activity, that the upper stage industry is saying that full cost recovery will somehow kill their business. And the difficulties that exist with some parts of the upper stage industry today are there even with low-cost, subsidized transportation. The problems that some of those upper stage industries are facing are rather that the market hasn't materialized as they expected or hoped it would, and that integral propulsion, in some cases, has affected that market, as well.

As a consequence, those upper stages are concentrating on Government business, Government business that would be totally outside the full cost recovery policy that this administration supports.

So in no way do we think that we are putting at risk those kinds of ventures, which 80 percent of some of those markets are reliant on Government payloads.

Mr. NELSON. You know, what would make for an excellent hearing is to get you and Secretary Dole and all of those upperstage industries in the same room at the same time——

Ms. DORN. With the doors locked? [Laughter.]

Mr. NELSON [continuing]. With a Sergeant-at-Arms standing at each door, and let you have at it.

Mr. Smith?

Mr. SMITH of New Hampshire. You led right into my question, Mr. Chairman. Thank you.

It just seems to me—I'm new on the committee and new in Congress, so maybe I'm just dumb and stupid enough to ask this question, but it just seems to me that we've been directed by the President to commercialize the ELV's and to have a commercial U.S. ELV capacity. The question is not whether we're going to have one, the question is how are we going to have one, how are we going to develop an ELV capability complementing NASA? And what I'm hearing as I sit here is bickering. I'm not suggesting that everybody should go to the woodshed like I believe some other gentlemen have a couple of times, but how are we going to resolve this problem? It's very difficult for us to sit here, as a Congress, and try to—I don't think we should be the referee—how are we going to—I don't want to use the word appalled, but I'm a little bit shocked, to really have public bickering here between an independent agency and, frankly, a part of the executive branch of the Government—how are we going to resolve this so that we can complement each other, so that NASA and the private sector can complement each other the way they are supposed to do under what I believe is the directive of the President and the Congress? How are we going to do this? I think that's the question, how? And I really haven't heard that yet. I haven't heard an answer to that question.

Ms. DORN. Well, in our view, Congressman, the answer lies in the President's policy; and I know I've stated it before, but implementing full cost recovery. Our industry has asked for no special treatment, no special opportunities, no giveaways from the Government. They have just said, "Let us have a fair opportunity to compete for the market. We have a technology that is comparable with Ariane. Customers out there have a need that they have mentioned for an expendable launch vehicle capability rather than relying only on the manned vehicle, which does a number of great things in other areas." And it seems to me that the implementation of a full cost recovery policy, using a standard definition, is going to accomplish the successful opportunity for the ELV industry to compete.

Mr. NELSON. Would the gentleman yield?

Mr. SMITH. Yes, sir, Mr. Chairman, certainly.

Mr. **Nelson**. Did I just understand the lady to state that the ELV industry had not asked for any special treatment? Is that what I understood the witness to say?

Ms. **Dorn**. Yes.

Mr. **Nelson**. Well, then, as I understand, the ELV industry had worked out an arrangement where it was 85 percent of value—is that the percentage that they were to purchase the hardware?

Ms. **Dorn**. I believe it was 87.5 percent.

Mr. **Nelson**. At 87.5 percent. And the range services, which happen to be in my congressional district, were to be provided not on the same cost recovery basis that you're talking about, of insurance and investment and depreciation and so forth, but pure marginal cost. So how does that square with the witness' statement?

Ms. **Dorn**. With respect to the first point, Mr. Chairman, the 87.5 percent figure was for the TCI Delta vehicle. It has been the traditional policy of the Government when equipment, or land, or any kind of facilities are no longer needed by the Government, that those are sold; and typically, the cost received is less than the acquisition cost for that hardware or whatever is no longer of need to the Government. That kind of policy was implemented in accord with the National Security Decision Directive which directed no direct subsidies, but on the other hand encouraging the expendable launch vehicle industry. In our view, that is consistent with Government policy for sale of property which is no longer needed.

With respect to the range costs, the range costs that have been determined by the Secretary of Defense will be the same to all users, both STS and ELVs. It is a service that is not in competition with the private sector because there are no commercial ranges. The STS, on the other hand, is in direct competition for those services which require an unmanned vehicle, and I believe that that policy is consistent as well with past Government practice.

Mr. **Nelson**. I'll pursue that a little later.

Excuse me, Mr. Smith, and thank you for yielding.

OK, now, let's see—who was next, now, Mr. Barton or Mr. Slaughter?

Mr. **Barton**. Well, I want to congratulate you, Ms. Dorn, for applying a principle. It's very rare that we get that applied in its totality.

I would ask you the same question that I asked the Director of NASA, and that is what you think the intent of the Commercial Space Launch Act was in 1984: to permit commercialization, or to allow it—I mean, to encourage it?

Ms. **Dorn**. To permit or——

Mr. **Barton**. In other words, was that act intended to just permit private enterprise in space, or to actually encourage it and go out and set a Government policy that did that?

Ms. **Dorn**. It was to help, Congressman, ease the way, both from the regulatory perspective and from the economic perspective. From the regulatory perspective, we were directed to deregulate an industry that had become overly consumed by regulations from a number of different agencies. So we were asked to streamline the process so that the Government would not stand in the way. That same principle applies to the economic side of the Government. And part of our role in the Executive order, as well as in the law, in the act, was to review the policies that the Government has to assure that they were in no way unfairly impeding the development of this private sector service. And I am taking great liberties at paraphrasing, and I'd be happy to provide for the record the precise point.

Mr. BARTON. OK. Have you mentioned in your previous testimony or in response to other questions what you think full cost pricing would be? Have you given us a dollar amount per launch?

Ms. DORN. To the chairman's chagrin, I have not. I have indicated that the administration is currently discussing the appropriate elements to include in a full cost recovery price, and we have not determined, as an interagency group, a recommendation that will be made to the President.

Mr. BARTON. Do you have a range?

Ms. DORN. No.

Mr. BARTON. You do not have a range?

Ms. DORN. Not at this point.

Mr. BARTON. OK. Well, I would suggest that, first of all, you are absolutely correct. If we're going to have full cost pricing, then the road that you're going down is the way to go. But we have an open market, and we're not talking about strictly the United States controlling that market. We've got a foreign competitor, the Europeans; they've got a good product, and it's my understanding that whatever we price our product at, they're going to come in 10 percent or 15 percent under us. So we do have to look at more than just pure free market principles.

Ms. DORN. Absolutely.

Mr. BARTON. And if we decide that we want full cost pricing of the space shuttle, and it appears that it's going to be somewhere in the range of—NASA says $87.5 million, CBO says $186 million, some private concerns have said $150 million—then we're going to lose the commercial payloads and we may lose the manufacture of those payloads. So that's a national policy objective.

Ms. DORN. Absolutely. And Congressman, we are very sensitive to that issue. And we believe, through our analysis and discussion with Arianespace and the consultations in section 301, that Arianespace has every motivation to increase its price. It prices now—to meet the shuttle competition, and when the shuttle goes to full cost recovery, Arianespace has admitted, in fact, that their price is, in fact, less than their cost. They are now operating at what I would call a margin. The value, the high value of the dollar makes an incredible difference in their alleged or apparent profitability. They have a strong economic incentive to maximize their return on the investment, and in fact ESA has indicated to us that there are competing areas in terms of investment that ESA must face, and to invest even more in capabilities in order to capture more of the market, the incentive is not there to do so.

Mr. BARTON. If I may interrupt——

Ms. DORN. Of course.

Mr. BARTON [continuing]. As long as they're willing, and they've indicated and history has shown that they are willing, as long as they're willing to subsidize their effort, no matter what we set our price at, how are we going to allow our private commercial launchers to compete? How can they ever compete?

Ms. Dorn. Well, right now, Arianespace sets their prices just a "widget," or a small percentage, below the shuttle. And we have every reason to believe that once full cost recovery goes into effect, that they will likely set their prices just one "widget" below whatever the price leader is.

We believe, however, that the commercial ELV industry is capable of competing, that they have a technology which is comparable, that they have financing and insurance kinds of opportunities and options and flexibility that the U.S. Government doesn't have. The fact that the shuttle may lose a few payloads in the commercial arena does not mean that they will automatically go to Arianespace. Our companies are able, willing, and ready to provide that U.S. domestic ELV capability that will effectively, I believe, compete with Arianespace.

Mr. Barton. May I ask one final question, Mr. Chairman?

Mr. Nelson. Certainly.

Mr. Barton. Well, let's assume, Ms. Dorn, that we do exactly what you say. And I would suggest that what Ariane would do would have a dual price track, that they would negotiate or bid for our commercial business below our private launchers, and that they would compete against NASA in those areas that the private launchers could not. And I don't think that our commercial industry would have a chance. Now, that's a personal opinion; that's not based on fact, that's just based on Texas A&M freshman economics. And, you know, Phil Graham taught down there and he knows a little bit about it. [Laughter.]

Ms. Dorn. Well, certainly, Congressman, there are certain commercial payloads which are shuttle-unique, LEASAT being one. We are not in any way trying to preclude the shuttle from participating in that market or competing for any payloads, whether they be shuttle-unique or not. Of course, there are some disadvantages, as Mr. Beggs so ably pointed out, to having an unmanned vehicle. There are only certain payloads that can be launched from an unmanned vehicle. So the slice of the market, the intersect, if you will, between the shuttle and ELV is a very small portion of the shuttle-capable market. And we believe that the domestic ELV are as able to compete with full cost recovery prices for that market as well—and in fact, in some cases, better—than the shuttle.

Mr. Barton. Thank you.

Mr. Nelson. On that particular score, let's take your hypothetical for the future, and let's see if there's any applicability to the past. A private ELV agency, authorized and certified, a company, authorized to do business by you, has been in a competition with Ariane. Now, what's happened in that competition?

Ms. Dorn. Well, in one particular competition where the prices were very close between TCI and Arianespace, the customer indicated to us, as I believe they indicated to you, that they were uncertain of the long-term stability of TCI. They sought a Government guarantee because of this in order to assure that their payload would, in fact, be launched. Now, the major reason, as far as our analysis goes, for that uncertainty was the pricing policy. No one out there believes that the U.S. domestic ELV's can compete with the subsidized launch system that is operated by the Government. So I would have trouble, if I were a customer, in gaining that same assurance until I saw in print the full cost recovery price as reflected in a Government policy for a specified number of years or a year or however we choose to do it. So that's understandable to me.

Mr. NELSON. Was the TCI bid lower than the Ariane bid?

Ms. DORN. I have seen two figures on that, and I'd be happy to provide it for the record.

But with respect to the basic point, the price for that particular bid was almost irrelevant because of the lack of confidence in the customer that TCI would be around to launch it. And most of that reason had to do with the question of the policies of this Government and whether we're unfairly going to compete with that launch vehicle system that's in the private sector.

Mr. NELSON. For some reason, the figure of four payloads sticks in my mind, that there were four competitions and in all four, the payloads went to Arianespace.

Ms. DORN. I have not heard that figure, but I would be happy to provide that for the record. I am aware of two——

Mr. NELSON. Was it two or four? Or five?

Well, isn't it being operated through your Agency?

Ms. DORN. No; absolutely not. The private sector goes out and competes on its own for potential payloads. So I would be happy to—I'm sorry that I don't have that information at hand, but I know that TCI has been aggressively and actively marketing, and has sought a number of bids. I just couldn't give you the precise number and the precise figures.

Mr. NELSON. OK. Does anybody have any more questions?

[No response.]

Well, you know, we've blown the schedule so bad, I'm going to invite you all over for a Florida orange juice to my office afterwards, but we need to ask just a few more questions here.

I want to give you a hypothetical here. Let's say that the shuttle is—we're not going to be flying any commercial and foreign payloads in our hypothetical, and we're going to be flying 16 flights a year. And so that's going to be primarily DOD payloads and it's going to be NASA science payloads.

All right, now. Do you have any estimate for how much it would cost NASA—well, you're not going to know that——

Ms. DORN. I resent that. No, I'm just kidding.

Mr. NELSON. If you know it, otherwise let me give you a figure of what we've heard over this.

Ms. DORN. OK.

Mr. NELSON. I don't want to put you on the spot with something that you might not be aware of, but it came out that there's going to have to be a certain cost that it's going to cost NASA to operate those 16 flights a year. All right. We get the figure somewhere between $1.5 billion, maybe $2 billion, and that's a fixed cost.

Ms. DORN. For the 16 flights?

Mr. NELSON. For the 16. You're up and you're running the 16; no commercial satellites.

Now, say in our hypothetical that a commercial operator comes forth and says, "I want you to fly a 17th flight." How much is it going to cost NASA to add that 17th flight?

Ms. Dorn. That sounds like a story problem, and I'm afraid I could not, at this point, answer the question, but I would be happy to provide that—oh, you're not——

Mr. Nelson. No, I can tell you from the record. The record today of Mr. Beggs says it will cost $33 million.

Ms. Dorn. In variable costs?

Mr. Nelson. He says that's his additive or marginal cost.

OK. Now, if all of that's true in this hypothetical, if that $33 million is the additional charge that he says that he would charge that commercial payload, that's his additional cost for that 17th flight, then why are you sharing with us that you think that that's a subsidized price, that 17th flight?

Ms. Dorn. Because we would only allow the marginal costs to be incorporated; is that what you're saying?

Mr. Nelson. What is the total cost to the Government for that 17th flight? Is the total cost to the Government for that 17th flight $33 million, or is it a greater figure, as you have stated in your testimony?

Ms. Dorn. Well, if we choose a policy which operates on marginal cost—in other words, whatever it costs for the next increment—we are now competing with the private sector. And in our view, full cost recovery is a more appropriate price than the marginal cost because in the NASA pricing policy, it's my understanding that we have scaled our level of projected flights to include commercial and foreign customers. And therefore, they should help in their contributions to the fixed base.

Now, the danger in not pricing full cost recovery, No. 1, it creates an incredibly unstable environment. If you are projecting a certain number of flights and you fail to meet those flights—as an example, the 24 flights per year that's estimated by NASA is what many, if not most, would consider a very optimistic flight rate. According to the National Academy of Sciences, the range might be, as you mentioned earlier in your testimony, from 17 to 24.

Now, if we discover that we fly in fact fewer than 24 flights, based on an $87 million cost, we in effect are making even less contribution to the fixed base. And so the pricing policy is so driven by the projected flight rates that it becomes very important. And if we are to lose, say, 2 to 4 commercial flights and accept NASA's estimate of what that would mean in terms of lost contribution to the fixed base, it would be in the area of $100 to $200 million.

Now, if, however, we had what we would consider to be a full cost recovery price, you could make up in volume what you lost in the particular item. So all of this is so variable in terms of what assumptions you use that NASA can, in fact, accomplish.

And when I mentioned the 24 flights per year, I would hasten to point out that in no way do we lack confidence in NASA's technical ability to accomplish 24 flights per year. We are talking about, however, contingencies, down time, those types of thing, turnaround times, that have not been accommodated for us. So if you project a very optimistic flight rate, and in fact you're unable to achieve it, that you have priced for 24, you in effect lose even more contribution to the fixed base. And that's what we're concerned about. That also gives a greater instability to the potential customer out there. He's never going to know what the price is because the Government has used a more optimistic flight projection than people actually believe is going to be accomplished.

Mr. **Nelson**. OK, let me explore just a little bit more, here.

You had earlier said that the Government ought to charge full cost for what it is providing, and earlier I had, on a followup to someone else's question here, I had pointed out that, for example, the launch facilities are not full cost; it's only the additive cost. There's no depreciation in there; there's no interest in there; there's no this or that. It's just the additive cost of that launch facility, the Eastern Space and Missile Center facility.

Now, I'm trying to understand how you can have one standard for one and another standard for another, and you answered me by saying that one was competition and the other one was not competition.

Ms. **Dorn**. With the private sector.

Mr. **Nelson**. Could you explain that again?

Ms. **Dorn**. Certainly.

The service that the range now provides is not in competition with the private sector because we don't have a private sector that's offering commercial range facilities. That's what I meant about not being in competition.

Mr. **Nelson**. I see that. I think it has been raised in other testimony before this committee that if you're going to ask for consistency on what should be recovery of cost, if you do it in one area you ought to do it in another. And the cost of hardware, such as the missiles themselves at less than 100 percent, and the cost of the range facilities that are provided, are not proposed to be recovered at full cost. You know, that's debatable. You have your opinion and you've expressed it, and others have expressed different ones.

Ms. **Dorn**. I understand.

Mr. **Nelson**. OK, let me see if we can wrap this thing up.

A week ago, I saw in the Post——

Ms. **Dorn**. Uh oh.

Mr. **Nelson**. As a matter of fact, it was on a Monday morning, an article in the Post, and it was about the Titan II's——

Ms. **Dorn**. I knew it.

Mr. **Nelson** [continuing]. And the Department of Defense and the Department of Commerce were gnashing their teeth to get ahold of those Titan II ICBM's rather than to go out into this commercial ELV market to launch their weather satellites.

Why don't you share with me your thoughts on this?

Ms. **Dorn**. Certainly, Mr. Chairman.

It's my understanding that the decision on the part of the Department of Commerce, as well as the Department of Defense, was strictly a budgetary one. In my discussions with Dr. Calio, he mentioned to me that a sharing of the recurring costs with the Department of Defense for their meteorological satellite would save him a considerable amount of money, and I believe that's quoted to be $100 million, if he were to fly on the shuttle. From the Department of Defense point of view, it's my understanding that all of these potential satellites are in polar orbits, they are very small payloads, and it is somewhat difficult to find partners for those payloads, given that particular orbit. So their decision, too, was based on the fact that they had these Titan II's lying around in storage, and they believe that to refurbish them would cost a less amount than to try to get those small payloads on a polar orbit on the shuttle.

Beyond that, I could not speak for them.

Mr. **Nelson**. As we close out this segment of the hearing—and we still have our third participant, bless his heart, he's been waiting a long time—I want you to understand that the testimony that this committee has received is that we have two sectors, two interests pulling and tugging on us as we take testimony. On the one hand, we have an industry that says that if you want us to be a viable industry, that you've got to get that shuttle price way up. And on the other hand, we have another segment of the industry that says that if you want us to be economically viable, you've got to bring that price down. And somewhere, we are trying to search for truth and to find that truth.

It has also been pointed out that one of the segments of these industries, the one who would want the high price, has invested a little bit of money already compared to the segment of the industry that has invested a considerably greater amount of money, by a factor of 20.

Then, as we try to search for truth, we look out into the future. What's going to be this industry? You've heard the figure, it's going to be a $60 billion industry, Mr. Beggs testified, by the year 2000. We asked in a previous hearing what percentage, as you move on into the 1990's, of that would be of commercial ELV's, and the testimony was less than 10 percent. So we're looking at this whole thing. You've got to understand, we're being pushed and pulled and bugged from two different sides.

You have articulately made the case which you stated, and I appreciate that.

I do want to make one clarification on something that you had said. You had made reference to the Commercial Space Launch Act, which was signed into law a year ago, which established DOT as the lead Agency for facilitating and regulating the private ownership of ELV's. I thought that I heard you say something to the effect that your Agency had the responsibility of rendering the policy and operation of that launch system. Did you say anything like that?

Ms. **Dorn**. I don't recall saying that, sir. I don't agree that that's the case.

Mr. **Nelson**. All right. Then I must have misunderstood you. If we had a written record I'd have it read back, but we're not getting into that.

Anyway, if anybody here misunderstood that, the act specifically excludes the Department of Transportation—specifically excludes the Department of Transportation—from having any legislative authority regarding the policy and operation of the Government launch system.

Ms. **Dorn**. Yes, and I totally agree with that. And I think you'll notice that in the next section it also makes the stipulation that this in no way would impede the Secretary of Transportation from her normal involvement in the Cabinet Council process and interagency, and that's all that we have sought to do, Mr. Chairman.

Mr. **Nelson**. Sure. OK.

Anybody? Any more questions?

[No response.]

OK. Thank you very much.

Ms. DORN. I appreciate it.

Mr. NELSON. Dr. Eric Hanushek is Deputy Director of the Congressional Budget Office.

You have been most patient, and we appreciate it. Here we are, almost 10 minutes until 6 o'clock, but we'll stay as long as you want, and I wish all you folks that are leaving wouldn't leave us. Stay through to the end.

Thank you, Dr. Hanushek. I appreciate your being here.

STATEMENT OF DR. ERIC HANUSHEK, DEPUTY DIRECTOR, CONGRESSIONAL BUDGET OFFICE, ACCOMPANIED BY DAVID H. MOORE, NATURAL RESOURCES AND COMMERCE DIVISION, CONGRESSIONAL BUDGET OFFICE

Dr. HANUSHEK. Mr. Chairman, if I might introduce Mr. David Moore, who is accompanying me today.

Mr. NELSON. Now, you work for Rudy Penner, is that right?

Dr. HANUSHEK. That's true.

Mr. NELSON. You used to work for Alice Rivlin?

Dr. HANUSHEK. We work for you, is the way we would state it.

Mr. NELSON. All right. OK. But your boss used to be Alice, and now it's Rudy?

Dr. HANUSHEK. Correct.

Mr. NELSON. OK. Well, you've got two fine bosses. Please proceed.

Dr. HANUSHEK. Mr. Chairman, if I might submit my whole statement for the record and try to highlight a few parts of this testimony?

Dr. HANUSHEK. I am pleased to appear before the subcommittee to discuss space shuttle pricing policy. The shuttle price is a key factor in determining the resources the Nation devotes to space and whether they are provided by the public or private sector. A high shuttle price could encourage private U.S. companies to enter the commercial launch market, but would leave the shuttle underutilized and possibly strengthen the position of the shuttle's main current competitor, Arianespace.

On the other hand, a very low price could encourage the use of the shuttle but limit private competition, subsidize commercial and foreign users, and possibly encourage unprofitable expansion of the shuttle system.

The history of the shuttle pricing policy is well known before the committee, and while my full statement goes into that, I will not go through that today. In the main testimony we tried to summarize two aspects. One is the cost of providing current services, and the second is how shuttle pricing policies would be linked to our space policy objectives.

Many of the numbers that appeared in our recent report on shuttle prices have been used already in this testimony and, in fact, they come from NASA itself. We used their numbers. The full testimony and the report go through them in detail. Let me just point out a couple of things about these prices—excuse me, the cost that we calculated first, and then turn to the linkage between prices and our space objectives.

We present two basic kinds of cost estimates in our report. One is the marginal cost of providing shuttle services, and the second is average costs, which are sometimes referred to as full costs, often in this testimony. These costs are, in fact, very sensitive to some key factors such as the shuttle flight rate, the depreciation and discount rate used to include any capital costs in the calculations, and the accuracy of NASA's operational cost projections and estimates.

In our cost estimates we have assumed an annual flight rate of 24 for our base cost estimates and have shown the sensitivity of the cost to alternative flight rates. We have calculated two different estimates of marginal cost. First is a short-run marginal cost which we price at $42 million per flight; the second is a long-run marginal cost which we price at $76 million per flight. The latter differs from short-run marginal cost in that it does include some capital cost for an additional fifth orbiter.

We also provide three different average, or full-cost, measures that range from $84 million, which is the average full operational cost—and it's the number that Mr. Beggs has concentrated on—up to $150 million per flight, which is an average total cost that includes all past and future costs of providing shuttle services.

Mr. Nelson. Does that include R&D?

Dr. Hanushek. Yes; it does.

We have an intermediate—our fifth cost that we present in our testimony, in our report, which is average full cost less the research and development that went into it—that number would be $106 million per flight. And again, as other people have done, we have given all cost estimates in 1982 dollars.

There is a lot of uncertainty about each of these costs, and we have provided ranges of both marginal costs and the full-cost estimates. The marginal-cost range of estimates are most sensitive to what you determine is the fixed operational costs and which are the variable operations costs. On the other hand, the full-cost estimates are very sensitive to the assumed flight rate, and as discussed before, we have used a 24-flight rate for our base calculations, but that may be optimistic and so we have also provided estimates for 18 and 12 flights.

Let me move on. We have provided the details and documented how we have arrived at all these costs in our report and are willing to answer any questions on those. Let me instead move on to talk about how shuttle prices can be linked to policy objectives.

Each of the alternative cost measures that I've described could be used as a basis for shuttle prices. The choice will directly affect how well the Nation's competing space objectives are met. The three objectives that are most sensitive to shuttle price are cost recovery, the efficient use of resources, and the encouragement of commercial activities in space.

Economic analysis suggests that a price equal to marginal cost of production tends to promote the efficient use of resources, which in turn suggests that prices set for Government enterprises should be based on marginal costs. But the shuttle system is not a conventional enterprise because many of the costs remain fixed, regardless of the number of flights. These high fixed costs make the goals of cost recovery and efficiency incompatible. Specifically, because of high fixed costs, the cost of providing an additional shuttle launch is significantly less than the average cost of a launch. Simply put, recovering average cost does not lead to efficient pricing, and efficient pricing does not result in full-cost recovery.

The short-run marginal cost price, $42 million per flight, sacrifices the goal of cost recovery to ensure that the shuttle has sufficient customers to maintain a high flight rate. This price forgives shuttle users from repaying the system's fixed costs, and implicitly holds full use of the shuttle to be a preeminent policy objective.

Our price, by the way, of $42 million corresponds to the price for the 17th mission that you talked about before, and it differs slightly from NASA's estimates. But it is conceptually the same as their $34 million figure that they were discussing.

Mr. Nelson. How can it be conceptually the same when it's different?

Dr. Hanushek. Both of them are trying to get at the same notion of how much added cost comes for expendable supplies and labor and so on, directly related to a cost. There is a difference of opinion on how much of the costs are fixed and won't be adjusted or cannot be adjusted with different flight rates, and that's why we get different numerical answers.

Mr. Nelson. OK. I'm not sure I understood that, but we'll just accept it for the record.

Dr. Hanushek. I'm afraid I missed a key part of the hearing, here.

Mr. Nelson. My comment was that $9 million is close enough for Government work. [Laughter.]

Dr. Hanushek. Well, it's a lot less than the billions of dollars that we talk about in other places in our testimony.

A shuttle price set at the short-run marginal cost would have no net budgetary implications as long as NASA's cost estimates are not underestimated. A short-run marginal cost price is valid, however, only if excess capacity remains in the shuttle system. In contrast, the long-run marginal cost price, $76 million per flight, adopts the perspective that serving the foreign and commercial markets requires capital costs to expand the system, as well as the operating costs.

From a budgetary perspective, the concept of a price based on long-run marginal cost provides a litmus test to help determine the needs for an additional orbiter. If the shuttle is fully booked at this price, then a new orbiter could be acquired with the confidence that its users would pay for its costs, which are already included in the long-run marginal cost price. But, as with the short-run marginal cost option, the advantages of a long-run marginal cost will not be achieved if operational costs are significantly underestimated.

It is frequently presumed that if cost recovery is to be emphasized, a full-cost price would best meet this goal. But this may not be the case if flight demand for the 1989 through 1991 period is misestimated. The prices of $150 million, which was the full cost or average total cost, and $106 million, which subtracted off R&D costs, are high enough to permit full-cost recovery if and only if 24 flights are filled and flown in 1989. In fact, however, revenues from the sale of shuttle services may be maximized by charging a price below the estimated average total cost.

Proponents of full-cost prices point out that if foreign and commercial users are charged less than full-cost, then they will reap, but not pay for, the benefits of past expenditures that went into the shuttle and its technology. Moreover, full-cost prices are more compatible to the cost structures faced by private operators of competitive launch services. But it should be remembered that the demand for the shuttle could drop dramatically in the face of high full-cost prices. Thus, paradoxically, a full-cost price could lead to the necessity of budgetary subsidies for the shuttle system. Full-cost prices would tend to reduce long-run Government involvement in commercial space activities, since they would discourage use of the shuttle and would reduce pressures to expand capacity. Such market information may, however, give a misleading signal about Government's appropriate role.

In terms of the long-run commercial development of space, there are two distinct aspects. The first is the promotion of a private launch industry using expendable launch vehicles, or ELV's, and the second is the support of further commercial and industrial and communication uses of space. The former objective is aided by higher shuttle prices, while the latter, for which launch prices are a business expense, is strengthened by lower shuttle prices.

At the shuttle's conception, its low projected cost led planners to believe that it would ultimately replace ELV's, but these low costs did not materialize and ELV's continue to be a viable option for many space payloads. Arianespace has priced its services to be competitive with the shuttle and plans to win a third of the launch market over the next decade. Potential private U.S. ELV firms claim that both the shuttle and Arianespace charge below-cost prices, and that if the full cost of service were reflected in their prices, American ELV's would be more competitive.

The implications of a low shuttle price, such as a short-run marginal cost price for space commercialization, are mixed. The commercial ELV industry simply could not survive, and the potential entry of other nations—Japan, for example—might be discouraged. Arianespace is hard to predict, but would probably attempt to remain competitive.

On the other hand, firms investing in shuttle-related launch technology would benefit most. These include companies that are designing upper stage rockets to lift into higher orbits payloads which the shuttle has placed in low orbit. Investors interested in new space processing techniques would also be encouraged, perhaps overly so, since the price would make no allowance for recapturing capital costs.

Without a more extensive analysis of demand and the cost of shuttle competitors, it is difficult to evaluate the relative prospects of domestic ELVs, Arianespace, and the shuttle, should the shuttle system charge a midrange price based upon longrun marginal costs or full operating costs. Much really depends on Arianespace's pricing policies and the launch demand that subsequently materializes.

Therefore, in summary, Mr. Chairman, the choice of a future shuttle price will implicitly set priorities among national space policy objectives. No single price for shuttle services can meet all of the Nation's space objectives. Some objectives, such as the efficient short-run use of the shuttle's capacity and the encouragement of commercial activities in space, are best met by a relatively low price, while others, such as the encouragement of a private domestic launch industry and perhaps full cost recovery, suggest a higher price. The new price proposed by NASA and now under review by the Administration represents an attempt to trade off these competing policy objectives.

[The prepared statement of Dr. Hanushek follows:]

Statement of
Eric Hanushek
Deputy Director
Congressional Budget Office

Mr. Chairman, I am pleased to appear before this Subcommittee to discuss space shuttle pricing policy for foreign and commercial users. The Congressional Budget Office (CBO) has analyzed the cost of the shuttle, developed a set of pricing options, and explored the implications of these options for space policy objectives.

The shuttle price is a key factor in determining the resources the nation devotes to space and whether these are provided by the public or private sector. For instance, a high shuttle price could encourage private U.S. companies to enter the commercial launch market, but would leave the shuttle underused and possibly strengthen the position of the shuttle's major current competitor, Arianespace. On the other hand, a very low price would encourage use of the shuttle, but limit private competition, subsidize foreign and commercial users, and possibly encourage unprofitable expansion of the shuttle system.

The shuttle launch price is not of equal importance in achieving all of the nation's space objectives. Regardless of the price charged commercial and foreign customers, the shuttle system probably will fly at least 12 to 15 flights annually from 1989 through 1991, a sufficient number to maintain U.S. national prestige in space technology and to contribute substantially toward meeting the nation's objectives in space science research. A significant portion of the shuttle's national security mission also could probably be met with a flight rate lower than the 24 annual flights projected by NASA.

BACKGROUND

The President soon will submit to the Congress a new pricing policy for shuttle launch services provided to non-U.S. government users from 1989 through 1991. These users are foreign governments and mature commercial enterprises requiring launch services for payloads such as communication satellites and remote-sensing satellites. [1]

The current price for a shuttle launch, $38 million plus fees for capital facilities and insurance, was set by NASA in 1977 to recover all operating and production costs, including orbiters and related equipment. [2] But by the early 1980s, the shuttle program was behind its technical schedule, and the market for launch services proved substantially smaller than expected, forcing NASA to spread its costs over a smaller number of flights. Accordingly in 1982, when NASA set the second pricing policy for launches

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1. In contrast, so-called "infant industries," (such as materials processing and pharmaceutical manufacture) receive free or very low cost transportation from NASA, until they approach financial self-sufficiency.

2. All figures in 1982 dollars.

in the years 1986 through 1988, the price is significantly higher. But at $71 million, it still will not recover all of the costs of the shuttle system. The Administration is now reviewing a new policy proposed by NASA for 1989 through 1991. This price--$87 million per flight--calls for the recovery of average operational costs only. It remains substantially less than the price implied by the original pricing policy to cover all operating and production costs.

In determining a price for space shuttle services, two sets of factors are considered. The first is the cost of providing shuttle services and how closely the shuttle price should be linked to the resources consumed by the use of the shuttle. The second is space policy objectives, because the shuttle price, in effect, sets priorities among conflicting space goals. But even with agreement on priorities, two major complications remain in pricing the shuttle. First, uncertainty exists about the level of demand for shuttle services four to six years in the future. Second, there is disagreement about how NASA cost estimates should be used to develop an appropriate price. As a result, the CBO analysis of cost bases for shuttle pricing includes both a base case and ranges around that base for each potential pricing option.

SHUTTLE COSTS

In the absence of a competitive market for shuttle services, either average or marginal costs can provide a basis for determining prices. Average cost is simply the total cost of providing a service divided by the number of units of service provided. For the shuttle, flights are usually thought of as the relevant unit. Marginal cost is the cost of providing an additional unit of service, or one more flight. While an additional shuttle flight entails increased costs for fuel and other expendable supplies, many other expenditures on facilities, equipment, and people are unaffected and do not enter into the calculation of marginal costs.

Three elements are key in the calculation of shuttle costs, and uncertainties about these lead us to consider ranges of cost estimates:

- **The shuttle flight rate.** The base case assumes 24 flights for 1989.
- **The depreciation rate and discount rate** used to calculate the annual capital charge for the shuttle's assets. The base case uses a 4 percent real interest rate and a 25-year system life.
- **The accuracy of NASA's operational cost estimates** and the division of operational costs between fixed and variable components. The base case uses the NASA total operational cost estimate and divides it equally between fixed and variable costs.

The CBO base case estimates, which are described in more detail in our recent report, include five alternative measures of costs (see Table 1): [3]

- **Short-run marginal cost**, $42 million per flight--operational cost of an additional shuttle flight.
- **Long-run marginal cost**, $76 million per flight--operational cost of an additional shuttle flight, plus the capital costs associated with providing services for foreign and commercial users.
- **Average full operational cost**, $84 million per flight--the average total operational cost of a shuttle flight. Unlike marginal cost, it includes fixed operational costs.
- **Average full cost less development**, $106 million per flight. This cost averages all shuttle costs, except research and development, over the number of shuttle flights.
- **Average full cost**, $150 million per flight. This measure averages all shuttle costs, both past and future, over all shuttle flights.

The estimated marginal costs are less than the average costs because the former exclude fixed costs that do not change as additional flights are flown. Uncertainty in these estimates is worth highlighting, as shown in the ranges in Table 2. The base case estimate of short-run marginal costs--$42 million per flight--lies in a range between $28 million per flight (roughly NASA's estimate) and $71 million per flight. The actual cost in 1989 will depend on the flight rate between now and then and on how well NASA has estimated future operating costs and has distinguished fixed from variable

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[3] Congressional Budget Office, *Pricing Options for the Space Shuttle* (March 1985).

TABLE 1. PRICING OPTIONS

Pricing Policy	Definition of Cost	Price Per Flight in 1989 (millions of 1982 dollars) With 24 Flights	Price Per Flight in 1989 (millions of 1982 dollars) With 18 Flights	Policy Implications
Marginal Cost Prices				
Short-Run Marginal Cost	Variable operational costs.	42	42	Maximum use of shuttle. Likely end to domestic expendable launch vehicles (ELVs). Direct competition with Arianespace. If NASA's costs are underestimated, revenues will not cover cost. High flight rate encourages future expansion.
Long-Run Marginal Cost	Variable operational costs, plus a capital charge for an orbiter dedicated to foreign and commercial flights.	76	76	Shuttle should maintain current market share and generate net federal revenues. Domestic ELV firms have little chance of success.
Full-Cost Prices				
Full Operational Cost	All operational costs. Approximation of proposed NASA policy for 1989 through 1991.	84	98	Largely the same as for long-run marginal price.
Full Cost Less Development	All operational costs, orbiters at replacement cost ($1.7 billion each), plus other investment but excluding research and development.	106	128	Shuttle will lose part of its market share unless Arianespace increases its price as well. Prospects for domestic ELVs improved but still uncertain. Less than full use of shuttle.
Full Cost	All operational costs, plus all investment valued at historic costs.	150	186	Shuttle loses all but specialized foreign and commercial payloads--flight rate will be below efficient level. Reduced net federal revenues. Domestic ELVs will do well, particularly if Arianespace increases price. Investors in new space processing may reduce planned spending. Little immediate need to expand shuttle system.

SOURCE: Congressional Budget Office.

NOTE: Estimates reflect base-case assumptions about interest rate and depreciation. Alternative assumptions would generally result in higher costs for options with capital costs. Operational costs based on estimates by NASA.

costs. The long-run marginal cost estimate is $76 million per flight--in a range between $62 million and $105 million. It adds to short-run marginal cost an annual capital cost that reflects a $1.7 billion replacement orbiter, which might be needed to service the foreign and commercial market.

TABLE 2. MARGINAL COST: RANGE OF ESTIMATES
(In millions of 1982 dollars)

Cost Bases	Cost per Flight
Short-Run Marginal Cost	
Low	28
Base case	42
High	71
Long-Run Marginal Cost	
Low	62
Base case	76
High	105

SOURCE: Congressional Budget Office.

Estimated full costs rise significantly as the estimated number of flights decreases, because fixed costs, either operational or capital, must be spread over a smaller base, as Table 3 shows. For example, if 18 rather than 24 flights are flown in 1989, the average full cost increases from $150 million to $186 million. With only 12 flights, it increases to $258 million.

TABLE 3. FULL-COST PRICES UNDER VARIOUS ANNUAL SHUTTLE FLIGHT RATES (In millions of 1982 dollars)

Full-Cost Prices	Number of Flights		
	12	18	24
Average Total Cost, Including All Capital Costs	258	186	150
Average Total Cost, Less Research and Development	170	128	106
Average Operational Cost (The NASA Base)	126	98	84

SOURCE: Congressional Budget Office.

SHUTTLE PRICES AND POLICY OBJECTIVES

Each of the alternative cost measures could be used as a basis for shuttle prices. The choice will directly affect how well the nation's competing space objectives are met. The three objectives most sensitive to shuttle price are:

- Cost recovery;
- Efficient resource use; and,
- Encouragement of commercial activities in space.

Cost Recovery and Efficiency

Economic analysis suggests that competitive markets yield prices approximating marginal costs and that such prices provide for efficient use of resources. When price exceeds marginal cost, society forgoes benefits because consumers are willing to pay more for the additional unit of the service than the value of the resources that went into providing it. Conversely, if marginal cost exceeds price, resources used to produce the service would be better employed in providing some alternative good or service. Thus, a price equal to the marginal cost of production tends to promote the efficient use of our resources, which in turn suggests that prices set for government enterprises should be based on marginal costs.

But the shuttle system is not a conventional enterprise because many of its costs remain fixed regardless of the number of flights. These high fixed costs make the goals of cost recovery and efficiency incompatible. Specifically, because of high fixed costs, marginal cost--the cost of providing an additional shuttle launch--is significantly less than the average cost of a launch. Simply put, recovering average costs does not lead to efficient pricing, and efficient pricing does not result in full cost recovery.

The short-run marginal cost price, $42 million per flight, sacrifices the goal of cost recovery to ensure that the shuttle has sufficient customers to maintain a high flight rate. This price forgives shuttle users from repaying the system's fixed costs, and implicitly holds full use of the shuttle to be a preeminent policy objective. A shuttle price set at this level would have no net budgetary implications, as long as NASA's cost estimates are correct. If costs prove to have been underestimated, however, the government could end up subsidizing foreign and commercial payloads.

A short-run marginal cost price is valid only if excess capacity remains in the shuttle system. In contrast, the long-run marginal cost price, $76 million per flight, adopts the perspective that serving the foreign and commercial market requires capital costs to expand the system as well as operating costs. From a budgetary perspective, the concept of a price based on long-run marginal costs provides a litmus test to help determine the need for an additional orbiter. If the shuttle is fully booked at this price, then a new orbiter could be acquired with the confidence that its users would pay its costs (already reflected in the shuttle price). But, as with the short-run marginal cost option, the advantages of a long-run marginal cost price will not be achieved if operational costs are significantly underestimated.

It is frequently presumed that, if cost recovery is emphasized, a full-cost price would best meet this goal. But this may not be the case if flight demand for the 1989 through 1991 period is misestimated. The prices of $150 million (full cost) and $106 million (full cost less development) are high enough to permit full-cost recovery if, and only if, 24 flights are filled and flown in 1989. In fact, revenues from the sale of shuttle services may be maximized by charging a price below the estimated average total costs.

Proponents of full-cost prices point out that if foreign and commercial users are charged less than full costs, then they will reap, but not pay for, the benefits of the past expenditures that went into the shuttle and its technology. Moreover, full-cost prices are more comparable to the cost structures faced by private operators of competitive launch services.

But it should be remembered that the demand for the shuttle could drop dramatically in the face of high, full-cost prices. Thus, paradoxically, a full-cost price could lead to the necessity of budgetary subsidies for the shuttle system. Full-cost prices would tend to reduce long-run government involvement in commercial space activities since they would discourage use of the shuttle and thus reduce pressures to expand capacity. Such market information may, however, give a misleading signal about the government's appropriate role.

The Long-Term Commercial Development of Space

There are two aspects to the commercialization of space: the promotion of a private launch industry using rockets--expendable launch vehicles (ELVs)--and the support of further commercial, industrial, and communication uses of space. The former objective is aided by higher shuttle prices while the latter, for which launch prices are a business expense, is strengthened by lower shuttle prices. The price that any user must ultimately pay depends importantly on the alternative suppliers in the launch market, and therefore CBO has concentrated on this element of commercialization.

At the shuttle's conception, its low projected costs led planners to believe that it ultimately would replace ELVs. But these low costs did not materialize, and ELVs continue to be a viable option for many space payloads. Currently, the shuttle's ELV competitors include Arianespace (an enterprise backed by the 11 nations of the European Space Agency), and, potentially, several private U.S. firms. The ELV industry offers launch services with rockets directly or indirectly developed by U.S. government efforts--Delta, Atlas Centaur, Titan and their European relative, Ariane. Arianespace has priced its services to be competitive with the shuttle and plans to win a third of the launch market over the next decade. Potential private U.S. ELV firms claim that both the shuttle and Arianespace charge below-cost prices and that, if the full cost of service were reflected in their prices, American ELVs would prove competitive.

Because a short-run marginal cost price is below the other prices CBO considered, it is the most direct way to encourage use of the shuttle. But existing U.S. ELVs would not be able to match such a price, and competition would focus on the Ariane rocket. Although the response of Arianespace is hard to predict, continued subsidies by its European supporters appear likely. As a result, the commercial market would probably continue to be shared between Ariane and the shuttle, with the shuttle gaining some relative advantage.

The implications of a very low shuttle price for space commercialization are mixed. The commercial ELV industry simply could not survive and the potential entry of other nations (Japan, for example) might be discouraged. Firms investing in shuttle-related launch technology would benefit most. These include companies that are designing upperstage rockets to lift into higher orbits payloads which the shuttle has placed in low orbit. Investors interested in new space processing techniques would also be encouraged, perhaps overly so since the price would make no allowance for recapturing capital costs.

Without a more extensive analysis of demand and the costs of shuttle competitors, it is difficult to evaluate the relative prospects of domestic ELVs, Arianespace, and the shuttle, should the shuttle system charge a mid-range price based on long-run marginal costs or full operating costs. While a shuttle price based on long-run marginal costs might be low enough to allow NASA to compete effectively with Arianespace, it could be too low to permit domestic ELVs to survive. Alternatively, under a higher price based on full costs (and perhaps a full cost less development price), the U.S. ELV industry could compete directly with Ariane and the shuttle. Although existing ELVs firms (those using the Delta and Atlas-Centaur rockets) would have a difficult time matching Ariane's price, they would have real incentives to invest additional funds in improving these rockets or in developing new ones. From this perspective, a competitive domestic launch industry would be best promoted by launch prices that reflect full costs, unsubsidized by governments.

These benefits could be jeopardized, however, if Arianespace undercut a full-cost shuttle price with a subsidized predatory price. If investors perceived that Arianespace would use its government subsidies to prohibit the entry of U.S. ELVs, then the development of the U.S. ELV industry could be thwarted. Thus, in addition to a higher shuttle price, an aggressive trade policy that seeks to eliminate Ariane subsidies might be a necessary precondition to investment in U.S. ELVs.

OTHER FACTORS

A significant aspect of pricing policy concerns the time for which the price remains in effect. NASA has proposed a three-year policy, covering 1989 through 1991. The rationale is that price stability is desirable from a marketing standpoint and that the detailed engineering and construction work on communication satellites must start at least three years before launch. A very long lead time, such as the six years from now until 1991, however, greatly increases the likelihood of errors in forecasting costs and demand. One alternative to the proposed policy would be to establish a pricing principle, use it to set a price for 1989, and then to update the price each year using NASA's most recent information on costs and flight rates. This policy would implicitly have foreign and commercial users share a portion of the risks with the U.S. government.

SUMMARY

In summary, Mr. Chairman, the choice of a future shuttle price will implicitly set priorities among national space policy objectives. No single price for shuttle services can meet all the nation's space objectives. Some objectives--such as the efficient short-term use of the shuttle's capacity and the encouragement of commercial activities in space--are best met by a relatively low price, while others--such as encouragement of a private, domestic launch industry, and perhaps full-cost recovery--suggest a higher price. The new price proposed by NASA, and now under review by the Administration, represents an attempt to trade off these competing policy objectives.

Mr. **Nelson**. Well, you have distilled it down as good as anybody, and we've had about 4 hours of testimony today; and you've summarized it in about 3 sentences. And I commend you for that.

Mr. Walker?

Mr. **Walker**. Thank you, Mr. Chairman.

Let me also commend you. I've done quite a bit of reading and studying on this issue over the last several weeks, and I took the CBO document home last evening and spent 1½ or 2 hours with it and I thought it was one of the best presentations that I've seen in terms of laying out the policy options that we had and the various costs associated with it. I found it very useful and valuable.

Let me understand—the $42 million that you say compares to NASA's $33 million, and I realize we do have figures all over the ballpark here, but let's go with your $42 million because I have an idea that that might be closer to real budgetary involvement than anything else we have on the marginal cost—at that figure there would be no budgetary involvement in terms of incremental cost; is that right? For a commercial flight?

Dr. **Hanushek**. That is correct, if all these costs are correctly estimated by NASA.

Mr. **Walker**. So if we wanted to develop a policy that would assure that the Federal Government had no budgetary involvement in flying commercial missions, we ought not go below that figure; is that right?

Dr. **Hanushek**. Yes.

Mr. **Walker**. OK. Now, on the upper end, if I understood, if you go to the full cost recovery that includes all of the R&D and everything else, you came out with a figure, I think it was around $150 million, didn't you?

Dr. **Hanushek**. Yes.

Mr. **Walker**. Now, we had pretty much said, as a committee—I think it's pretty much acknowledged here that that's not a figure that we're particularly interested in, that we figure we've written off most of those R&D costs so that the next figure down is essentially full cost less development.

Dr. **Hanushek**. Yes.

Mr. **Walker**. And your figure is around $106 million?

Dr. **Haushek**. Correct.

Mr. **Walker**. And if I understood your study furthermore, you said that at $106 million—it would be marginal as to whether or not the ELV industry in this country could compete, but there might be a potential for their competition at that price. Is that essentially——

Dr. **Hanushek**. Well, we're trying to hedge that because we don't really completely understand the cost structure of the private ELV industry, and we've relied upon a lot of assertions that are difficult to track down.

Mr. **Walker**. But I gather that you guessed that there might be some ability for them to compete at that price, based on what you know?

Dr. **Hanushek**. Yes.

Mr. **Walker**. Now, what I've been suggesting here through the day is that, given those two parameters, that what we might want to do rather than setting one firm price would be to set up a structure that would allow a variety of pricing within that structure, taking into account some of the various policy problems that you raise. In other words, speaking to your summary there, that indeed that is the problem; and if you come up with one price, it is always going to be a compromise price. It's going to compromise at least a part of your national goal, and it might be better to have a policy that at least sought to ameliorate some of those compromises by having different prices based upon differing situations, at least over the transitional period between 1985 and 1995.

I just appreciate your comments, based upon the study that you did.

Dr. **Hanushek**. I think that there are two key elements in such a proposal. The first is—I think it's incumbent upon the Congress and the people making decisions on pricing to really specify which of the objectives it wishes to meet. Because just offering a range of prices does not say anything about what NASA should be doing. NASA could use a range of prices—for example, to maximize revenue, using your own numbers that you gave, if NASA wanted to maximize revenue it would pick the one user that was willing to pay the $100 million, and charge it $100 million; it would pick the 6 users that were willing to pay $71 million, and would charge them $71 million; and so forth down the line, if it wanted to maximize its total revenues.

Presumably there are other objectives, though, that NASA has that relate to efficient use of existing resources, that relate to what kinds of commercial activities it wants to foster, so that simply allowing NASA to have a range of prices does not obviate the need for making some choices about the kinds of objectives that we should pursue.

Second, there's a very important element here, and that is what expectations you set up in the market for potential users. Do potential users know what NASA is going to charge, or at least some range? We are now talking about prices relating to the 1989 to 1991 period. That is on the presumption that long lead times have to be given to firms in order to develop their uses of the shuttle.

At the same time, if we're going to have a policy like that we have to provide them with just what the expectations are of the prices that they're going to face; and so, if NASA waits until 1989 to set its prices for 1989 or 1990, it might introduce some uncertainty that would, in fact, harm the market for use of space.

Mr. **Walker**. OK. I think those are good points, and I think that is something that we would have to address. I mean, we obviously can't set up a policy that just says, "That's the policy and you go from there," I mean, I think you would have to set up some parameters. For instance, if you had a mature commercial vehicle that you're going to fly, that in fact that's the kind of thing that we're looking at at the upper range. If you've got a developing commercial vehicle, such as electrofroesis, that's the kind of thing that you want to look at at the bottom end; and indeed, to some extent, that might have to go through a bidding process. We may have to empower the commercial office at NASA to be somewhat selective in this in terms of the bidding process, because I would guess that you're right, that if you lowball some of those figures for some of the developing industries, you're probably going to encourage far more development or ideas than you have the capacity to fly. I happen to think that's a plus, not a minus, when all is said and done, because those are ideas that ultimately will find flight room in the future, so the more people you can get thinking based upon a lowball price, it seems to me it has some merit.

But I don't think that what you've raised there are irresolvable problems——

Dr. **Hanushek**. I don't think that they're irresolvable at all, but I think that we're best off specifying what prices we're going to charge for these things up front so that we can, in fact, try to match these national objectives to what goes on.

Mr. **Walker**. But should Congress be the one in the business of deciding, on almost a case-by-case basis, that this price fits that policy? You know, again, I think you're going to see a magnitude of technological and economic change based upon space over the next 10 years that is just going to be enormous. For Congress to sit here on a case-by-case basis and try to set those prices doesn't seem to be very astute. For NASA even, there's going to be somewhat of a problem if NASA doesn't have some idea of what the real market price is as compared to ELV's or Ariane. And I guess the real problem is, then, that if we take your analysis, then there is some sense in us coming along and saying, well, the price is $71 million, or the price is $87 million, and at that point we have canceled out a whole bunch of options. At $71 million we have canceled out the commercial ELV industry; we have given them no chance to compete whatsoever, because I don't think anybody says that they're going to come in. We have also managed to cancel out a good portion of the electroforesis experiments that would probably fly, so we've done harm on both ends of the spectrum to arrive at a compromise price that may be a totally unrealistic compromise price in the year 1991.

Dr. **Hanushek**. If I might add just one footnote to that, and that is that we are talking really about the price that is charged to mature commercial activities, the communications satellites and so forth, and not to the research and developing infant industries. And so we think that there is merit, in fact, in providing a much lower price while they get going, even during a risky R&D stage for some certain materials processing.

Mr. **Walker**. Yes, except that we're going to have some very fine lines to walk very quickly, that we are going to have basically new industries flying that could be—yes, they're very risky, they're risky R&D. But the fact is if they work as well as the guy who thought them up thinks they're going to work, they're also going to be extremely profitable down a very, very short stream. And you know, those decisions are going to be very, very tough decisions for NASA to be making. My guess is, though, that we want to let them have a price that will allow them to make a decision there, to go with them as quickly as possible because those are the ones that are going to pay off more quickly than others, too.

And so it just seems to me that perhaps you want a pricing structure that can be responsive to that, rather than a locked-in pricing structure that has no flexibility in it.

Dr. **Hanushek**. I entirely agree with that.

Mr. **Walker**. Thank you, Mr. Chairman.

Mr. **Nelson**. Mr. Smith?

All right, just a couple questions and we'll wrap up here for the day.

Do you have an opinion on which pricing policy option would produce the maximum level of income to the Federal Government?

Dr. **Hanushek**. We haven't completely worked that out. We don't have the estimates that would support a specific price estimate. We're convinced that the low price estimate, short-run marginal cost, or the very high one of average total cost or full cost, would almost certainly not produce the maximum revenue, and there is some in-between price. But exactly where that is, it's hard to estimate, in part because we don't completely understand what this future demand will be; and in part, we do not understand what Arianespace's pricing policy will be in response to ours.

Mr. **Nelson**. And would your answer be the same as to where you could maximize the economic efficiency of the shuttle?

Dr. **Hanushek**. No, there it would not be. In terms of defining economic efficiency as using our resources best, there we think that our marginal cost pricing is the appropriate pricing, and I think that the long-run marginal cost pricing in fact is appropriate in that it—if, in fact, we do not have excess capacity to accommodate all of the private uses—as long as there is excess capacity, then in the short term, the short-run marginal cost pricing would be the most efficient one.

Mr. **Nelson**. In other words, your theory there is the lower you get it down, the more use of it you're going to get?

Dr. **Hanushek**. That is absolutely correct.

But the problem is, if it gets too low, you've run into capacity constraints.

Mr. **Nelson**. OK. I understand.

Let me ask you this. Is marginal cost pricing used elsewhere in the Federal Government, by the Federal Government?

Dr. **Hanushek**. There are places that approximate marginal cost pricing. It turns out that the Federal Government, as best we can tell, uses a great variety of pricing methods. There are what comes out to be close to marginal cost pricing in some of the selling of irrigation water, in some of the selling of power, excess water or power out at Bonneville, power plants. There are examples that we think come close to marginal cost pricing where we are selling into a competitive market, such as in timber sales or in some of the oil sales where we're selling out of petroleum reserves. We suspect that those prices come close to marginal cost pricing. Usually they are not described that way and we have not done a complete analysis to confirm that, in fact, they are what we are calling marginal cost prices.

Mr. **Nelson**. OK. Any questions from anybody?

[No response.]

Mr. **Nelson**. OK. I can't even remember when our next hearing is.

OK. The committee will stand in adjournment, and we will reconvene tomorrow morning at 9:30. And thank you all for being with us.

[Whereupon, at 6:10 p.m., the subcommittee recessed, to reconvene at 9:30 a.m., Wednesday, March 6, 1985.]

1986 NASA AUTHORIZATION

WEDNESDAY, MARCH 6, 1985

House of Representatives, Committee on Science and Technology, Subcommittee on Transportation, Aviation and Materials, and the Subcommittee on Space Science and Applications,
Wasnington, DC.

The subcommittees met, pursuant to notice, at 9:35 a.m., in room 2325, Rayburn House Office Building, Hon. Dan Glickman (Chairman of the Subcommittee on Transportation, Aviation, and Materials) and Hon. Bill Nelson (Chairman of the Subcommittee on Space Science and Applications) presiding.

Mr. **Nelson**. The joint subcommittees will commence, and I will call on the TAM chairman, the Honorable Dan Glickman, the sunflower from Kansas.

Mr. **Glickman**. If I'm a sunflower, what are you?

Mr. **Nelson**. An orange.

Mr. **Glickman**. All right.

Thank you, Mr. Chairman. It's a pleasure to work with you on our first joint hearing of the year, in which we hear testimony from offices of NASA which are of interest to both subcommittees. It's my understanding that Mr. Newman, the Comptroller, will provide for us an overview of changes in emphasis in this year's budget request and may mention economic assumptions used in preparing the NASA budget proposal.

The statement of Mr. Hosenball, General Counsel, will include discussion of an amendment to the Space Act affecting patent rights to inventions made in outer space on a U.S. space vehicle.

Mr. Nysmith, Associate Administrator for Management, will discuss an absolutely vital aspect of NASA's operations, its manpower. This part of the budget request calls for an increase of seven-tenths of 1 percent over last year, and we can expect a Civil Service staff reduction of about 200 administrative workers under this budget proposal.

General McGarvey, Director of Facilities and Engineering, will discuss the planning, engineering, construction, and maintenance of NASA's many facilities. He will discuss NASA's various real properties, from laboratories to the launch facilities which support space transportation operations.

We look forward to hearing the statements which these four gentlemen have prepared.

Thank you, Mr. Chairman.

[The prepared opening statement of Mr. Lewis follows:]

HON. TOM LEWIS OPENING STATEMENT FOR NASA AUTHORIZATION HEARING, MARCH 6, 1985

Thank you Mr. Chairman. I join you in welcoming our distinguished witnesses this morning and I look forward to hearing their testimony. NASA's staff and facilities are indeed an important element in NASA's success.

I am disturbed at the continuing downward trend in NASA's complement and the effect this could have on NASA's ability to hire new science and engineering graduates. It is extremely important to continually bring in fresh new talent if NASA is to maintain the capability to do innovative research.

Facilities also need to be continually upgraded, so I am pleased to see NASA's plans to modify the 16-foot transonic tunnel at Langley. Modernizing existing facilities to increase their productivity is especially important in today's fiscal environment.

I am sure these gentlemen have a lot to tell us this morning and we will probably have many questions about their management and facility plans. I look forward to an interesting hearing.

Thank you.

Mr. NELSON. All right. We're delighted to have you.

Mr. Newman?

STATEMENT OF C. THOMAS NEWMAN, COMPTROLLER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY TOM CAMPBELL, DEPUTY COMPTROLLER

Mr. NEWMAN. Thank you, Mr. Chairman. With me at the table is Tom Campbell, the Deputy Comptroller.

I'm here to give you an overview of our budget request, and I believe you have these blue booklets; I'll use the first 9 pages of those booklets as my statement.

Our total budget request, as you can see, is for $7.886 billion of budget authority, and $7.772 billion of outlays. It's an increase of 5 percent over the fiscal year 1985 level, so we're just about 5 percent over the level that's been approved for the current year.

But within that total, we do have a significant amount for space science and applications, about 15 percent. The Aeronautics Program is at essentially the same dollar level in constant dollars as in 1985. And if you look at the total of the Space Transportation Programs, the space transportation capability development, the shuttle production and operational capability, and the space transportation operations, the combination of those three is just about even between the 2 years. Operations is up about $400 million—I'm—yes, operations is up $400 million; the operational capability is up just over $100 million, and production is down about $500 million. So they just about balance off.

Space station is up from the $150 million level in fiscal 1985 to $230 million in fiscal 1986.

Mr. NELSON. Now, which chart are you on?

Mr. NEWMAN. I'm sorry. I'm on page 2.

Mr. NELSON. OK. All right. Now I see where you are. All right.

Mr. NEWMAN. I'm on page 2, and I pulled together the second item listed, the space transportation capability development, the shuttle production and operational capability, and the shuttle operations—space transportation operations, the combination of those is the amounts that I said; it's just about equal between the 2 years.

Space station increases, but not as rapidly as we had anticipated last year, and I think you're aware of that difference.

We do have the new provision for the commercialization, Commercial Use of Space Program, at $30 million.

And, as Mr. Glickman mentioned, the Civil Service staffing in fiscal 1986 is at 21,800 as opposed to the 22,000 full-time equivalents for fiscal 1985.

Now, I want to mention, with respect to the request for research and program management, the 1986 figure is based on salaries 5 percent below the present pay rates. If the present pay rates were continued, we would require an additional $42 million, so we have that built into the budget. In the fiscal year 1985 column we are assuming a supplemental appropriation of $23.3 million to cover the pay rates that are currently in effect. And that's a partial coverage; we would be absorbing about $7.7 million of the total requirement.

On page 3, I just attempted there to lay out the total flight program and show the amount of activity in the Agency. It's kind of hard to do on a single piece of paper, but you can see there the shuttle missions at 10 missions in fiscal 1985, 14 in fiscal 1986, 17 in fiscal 1987, building up to 24 missions a year by 1989. These are all missions. They include the payloads of foreign and commercial users, as well as the Department of Defense and NASA.

Another point I'd like to make, and it's hard to show on this chart, there is a lot of activity using spacelab hardware, both as the full, combined, pressurized modules, and as partial modules. For example, in fiscal 1986 we have the first dedicated life science payload. We have the Astro-1 mission, which is a group of telescopes that, among other things, will look at Halley's comet; we have the sun lab; we have the materials science lab; we have a high energy astrophysics lab, all of these being experiments using spacelab hardware, and we have Earth observation experiments.

In 1986 we also, as you know, have the first flights of the Centaur upper stage, both for the Galileo mission and for what we now call the Ulysses mission, the former solar polar mission, that goes out to Jupiter, using Jupiter's gravity to get it to a latitude out of the plane of the ecliptic, and observes the Sun from latitudes that we've never been able to observe before.

There's a lot of flight activity. We also have the Hubble space telescope launched in 1986, and the Voyager/Uranus encounter. And we are providing for a good deal of development for future missions. You have the cosmic background explorer; you have the Venus radar mapper; the Mars observer; you have the advanced communication technology satellite, you have the Scatterometer, which will fly on a Navy spacecraft to study the oceans; we have the extreme ultraviolet explorer, and we have a lot of payloads in the plans to take advantage of the shuttle and spacelab capability.

So the main point I was really trying to make with that chart is that even though we don't have a new initiative in science and applications in 1986, we do have a lot of ongoing activity.

Now, on page 4, I am showing the shuttle operations in a way slightly differently than you usually see them. You usually see only the NASA funding. The total funding for shuttle operations are the figures shown there, the $1.604 billion in fiscal 1984; $1.832 billion in fiscal 1985, and $2.138 billion in fiscal 1986. Those amounts include the reimbursements that we expect to get from the Department of Defense and from the commercial sector.

The Department of Defense reimbursements in fiscal 1985 are $330 million. In fiscal 1986, they are down to $155 million. That's because the funding arrangement we have with DOD holds firm the payment in the year that has already been budgeted, but allows them credit in the subsequent year for the flights not flown. So the figure is down in 1986 because of credits for prior payments, but will be back up in fiscal 1987, and we do have an agreement on that amount with DOD at slightly over $500 million.

Mr. **Nelson**. I'm curious. What do you think that reimbursement might be by 1989, 1990?

Mr. **Newman**. Well, we're projecting out there, in that period, that the DOD reimbursement will be in the $600 million or $700 million range.

Mr. **Nelson**. That's pursuant to the new agreement?

Mr. **Newman**. Under the new agreement if they use about a third of the missions, or 8 or 9 missions a year, it would be in that range.

The fiscal——

Mr. **Nelson**. How about the commercial?

Mr. **Newman**. We're projecting the foreign and commercial reimbursements will be in the order of $500 million.

Mr. **Nelson**. So you're in excess of $1 billion, then, in reimbursement? About $1.1 billion?

Mr. **Newman**. Yes, sir. In that time period we are projecting that the total shuttle operational cost will be on the order of $2.5 billion a year of which, as you say, about $1.1 billion to $1.2 billion will be reimbursable, and the rest will be funded by NASA.

Mr. **Nelson**. It's looking better all the time.

Mr. **Newman**. In fact, we're requesting $1.725 billion in fiscal 1986. We believe our request for fiscal 1987 will be about $250 million below that figure, because the reimbursements will be picking up more of the load.

Mr. **Nelson**. Now, those reimbursements come back to you, directly to NASA, don't they?

Mr. **Newman**. They do, and we apply them to offset appropriated fund requirements.

So those are the key points that I wanted to make on that chart.

On page 5, again just to give you an overview of the Science and Applications Program, we are requesting $1.613 billion for those programs. I won't go through the details, but I've shown there the amounts for the major projects and the total estimated cost for those projects.

Now, the science budget in this year represents 25 percent of the total for the research and development and space flight control and data communications appropriations. You may remember that we had some discussions under which we committed that we would keep that at about the current level, and actually we have increased the portion of the budget this year that goes to the science and applications.

Mr. **Nelson**. Now, would you run that through again? Science and application is 25 percent of what?

Mr. NEWMAN. The two appropriations—when we originally reached the understanding that research and development covered both the areas that we cover now in the research and development appropriation, and the new appropriation called space flight control and data communications—if you take the sum of those two appropriations, the space science amount is about 25 percent of that total.

Mr. NELSON. And what percent is it of your total budget? Well, it would be roughly——

Mr. NEWMAN. I think it's about 20——

Mr. NELSON [continuing]. 20 percent.

Mr. NEWMAN. Yes.

Mr. NELSON. I see. OK.

Mr. NEWMAN. But when we discussed it, it was on the other basis; so, consistent with that, we're right at about 25 percent.

Page 6 is a reflection of our present operating plan for fiscal 1985, compared to the budget that we submitted to you at this time last year.

One thing I wanted to mention. In space station, we have $150 million, which is the amount budgeted, but there is also another $5.5 million in funds that were carried over from fiscal 1984 to be applied, so the real plan is $155.5 million.

In space transportation capability development we have a reduction of $10 million. That's largely because of savings in the spacelab. The flow of the spacelab through its initial checkout and flight was smoother than we anticipated. The hardware deliveries have come less expensive than anticipated, partly because of the favorable exchange rates, so we've had a benefit there and we were able to reduce the total. We have applied $6 million to the shuttle derived launch vehicle studies, consistent with the actions of the Congress.

The other changes—in physics and astronomy we show the same dollar level but we have augmented the research and analysis activity and the theoretical physics within that, specifically within that—consistent with the actions of the committee. We did augment planetary research and analysis, and you see us forming an increase there.

In space applications, we've increased the total by $30 million. Two major items in there; we added $40 million for the advanced communication technology satellite. We did increase materials processing. We did take reductions in the upper atmosphere satellite and the scatterometer, and also in the multispectral linear array. And we have written you on those.

In aeronautics, we're at the same dollar level but we have an increase of $10 million for the advanced turboprop and a reduction of $10 million R&T base.

There are also several items the committee recommended within the R&T base, and I believe we've met all of those items, at least to some extent, within the present plan.

In shuttle production and operational capability development, we are up $26.5 million. We are also above the authorization in that area, and Mr. Beggs signed a letter to you recently consistent with section 104 of the Authorization Act, explaining those increases. We do have the funds in there for the structural spares.

In operations we're down $25 million, and that's because of the changes in flight rates, and it is consistent with the committee's actions on the authorization. So we've taken a hit, in effect, of the $4 million plus the $14 million in that area, assuming that we get the full supplemental request.[1]

Mr. **Nelson**. Let me stop you right there. Your aeronautical research, $342 million. What are you requesting for that for 1986?

Mr. **Newman**. It's $354 million.

Mr. **Nelson**. OK. And that increase--you've got that checked out?

Mr. **Newman**. Well, yesterday we talked to the head of Aeronautics and they provided a reasonably satisfactory explanation of the authorization. So we've taken a hit, in effect, of the $4 million plus the $14 million in that area, assuming that we get the full supplemental request.

Mr. **Nelson**. Let me stop you right there. Your aeronautical research, $342 million. What are you requesting for that for 1986?

Mr. **Newman**. It's $354 million.

Mr. **Nelson**. OK. And that increase—you've got that checked out?

Mr. **Glickman**. Well, yesterday we talked to the head of aeronautics and they provided a reasonably satisfactory explanation for the numbers they have presented to us. So there will be a little bickering about the composition of that, but I cannot argue with the aggregate numbers that they've sent down.

Mr. **Nelson**. Fine.

Mr. **Newman**. The follow-on of the advanced turboprop in fiscal 1986 requires a significant increase over 1985, and I think it's from $10 million to $28 million. I'd have to check my numbers. There is a significant increase there.

On page 7, I just am showing the chart I have shown for years in this sense, showing that although we have increased by about 94 percent in actual dollars in the last 8 years, if you take that in the terms of constant dollars, it's just about an increase of 8 percent; or in terms of constant dollars, if you average it over time, we've been increasing by about 1 percent a year.

Mr. **Nelson**. Please go ahead.

Mr. **Newman**. On page 8 I tried to lay out some of the economic benefits of the NASA Program. We reworked out employment estimates this year; we went to both aerospace contractors and to some of the support contractors to try to get a better understanding of what employment they are really generating from the NASA programs, and we believe the appropriate amount is about 133,000 in the contract sector, plus our Civil Service complement, so that about 155,000 people get their jobs directly from NASA expenditures. On top of that, if you apply a fairly conservative multiplier effect of 2.5, you would see that NASA employment generates about 390,000 or 400,000 jobs in the economy. And these jobs are, for the most part, challenging jobs; they are jobs that pull the technology and the capabilities of the economy along.

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[1] Research and Program Management is $1,317.0 million, which is $1 million above authorization, and we notified the committee. That does not reflect a $4 million rescission that with be taken in fiscal year 1985 consistent with the Deficit Reduction Act and that is $14 million below the $1,331.0 million requested for fiscal year 1985.

We referred back here to some studies that have been done over the years that say that investment in NASA appropriations provides a stimulus to the economy. One study said about seven times the amount invested; a second study by Chase Econometrics said that that was a little too conservative, that the stimulus was somewhat greater than that. And, of course, it produces new products, new capabilities in the economy.

And one other key point. The aerospace sector enjoys a favorable balance of trade, something over $10 billion last year and it's projected to be about $14 billion this year——

Mr. NELSON. And I commend you on that. Mr. Beggs mentioned that yesterday afternoon. And you know, we're running a trade deficit of $163 billion; and yet, aerospace is contributing a $10 billion surplus to us. So I commend you on that.

Mr. NEWMAN. Thank you.

The last page I'll cover is page 9, and there I wanted to show the future year projections as they appear in the President's budget.

In fiscal 1986, we're at $7.886 billion. We hold about that same level for the next 2 years, and then in 1989 and 1990 you can see that we are catching up or building up again, to about the level that would be a straight projection of 1 percent growth over the whole period.

Now, the remainder of the blue book is detail of the programs by area. I won't go through that this morning, but this gives you a short summary of the budget in each of the program areas that the Associated Administrators have already covered with you.

It also gives you a description of the key activities at our Centers.

And with that, I've concluded my prepared statement.

[The prepared statement of Mr. Newman follows:]

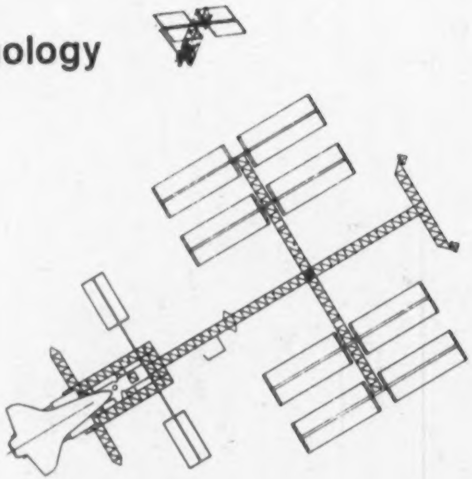
NASA
National Aeronautics and
Space Administration

Hold for Release Until
Presented by Witness

March 6, 1985

Subcommittee on Space Science and Applications
Committee on Science and Technology

House of Representatives



Statement by:

C. Thomas Newman
Comptroller

99th Congress

NASA FY 1986 BUDGET SUMMARY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

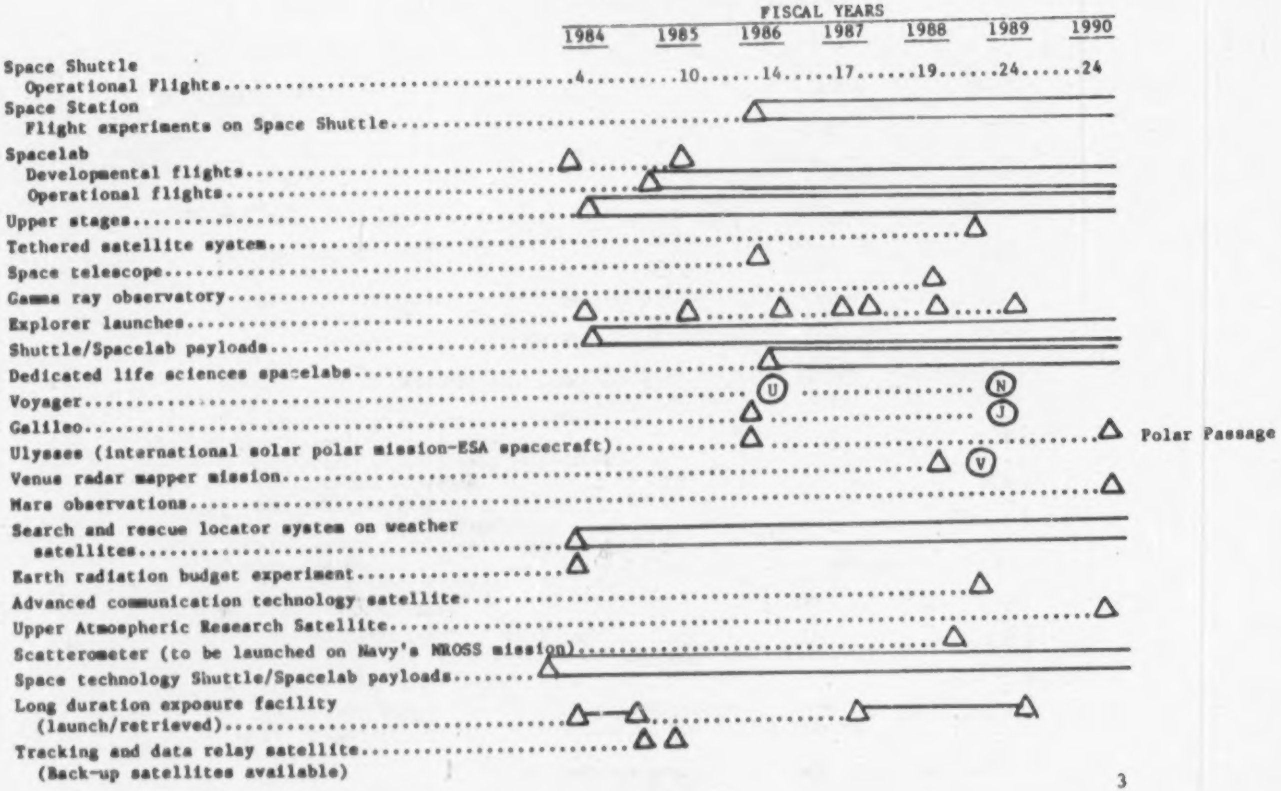
FY 1986 BUDGET SUMMARY
(Millions of Dollars)

	FY 1984	FY 1985	FY 1986
RESEARCH AND DEVELOPMENT	2,064.2	2,422.6	2,881.8
Space Station	(21.9)	150.0	230.0
Space Transportation Capability Development	431.7	351.4	459.3
Space Science and Applications	1,157.0	1,404.5	1,613.2
Technology Utilization	9.0	9.5	11.1
Commercial Use of Space	---	(8.5)	30.0
Aeronautical Research and Technology	315.3	342.4	354.0
Space Research and Technology	137.0	150.0	168.0
Tracking and Data Advanced Systems	14.2	14.8	16.2
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	3,772.3	3,601.8	3,509.9
Shuttle Production and Operational Capability	1,646.3	1,492.1	976.5
Space Transportation Operations	1,452.0	1,314.0	1,725.1
Space & Ground Network, Comm. and Data Systems	674.0	795.7	808.3
CONSTRUCTION OF FACILITIES	155.5	150.0	149.3
RESEARCH AND PROGRAM MANAGEMENT	1,255.9	1,336.3[a/]	1,345.0
TOTAL	7,247.9	7,510.7	7,886.0
OUTLAYS	7,047.6	7,317.0	7,772.0
CIVIL SERVICE FULL TIME EQUIVALENTS	22,080	22,000	21,800

[a/] Includes $23.3 million for a proposed pay raise supplemental offset by a proposed rescission of $4.0 million related to the 1984 Deficit Reduction Act.

National Aeronautics and Space Administration

FLIGHT ACTIVITY



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1986 CONGRESSIONAL BUDGET

SHUTTLE OPERATIONS

	FY 1984	FY 1985	FY 1986
Flights	4	10	14
Funding (millions of dollars)			
NASA	1402	1314	1725
Reimbursements	202	518	413
Total	1604	1832	2138

2/27/85

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 CONGRESSIONAL BUDGET
(Dollars in Millions)

SPACE SCIENCE AND APPLICATIONS	FY 1984	FY 1985	FY 1986	TOTAL
Hubble Space Telescope	195.6	195.0	127.8	1175
Hubble Space Telescope Operations/Maintenance	41.5	74.7	88.0	
Gamma Ray Observatory	85.9	117.2	87.3	425-475
Explorers Development	48.7	51.9	55.2	
Shuttle/Spacelab Payloads and Mission Mgmt.	143.1	167.7	219.2	
Galileo	79.5	56.1	39.7	830-910
Ulysses	6.0	9.0	5.6	140-170
Venus Radar Mapper Mission	29.0	92.5	112.0	350-400
Mars Observer	—	13.0	43.8	300-375
Upper Atmosphere Research Satellite Mission	20.0	55.7	134.0	630-700
Advanced Communications Technology Satellite	25.0	45.0	90.0	325-425
Research and Analysis	255.4	269.6	289.6	
Sounding Rockets/Balloons/Research Aircraft	52.5	58.7	62.4	
Mission Operations, Geodynamics, ERBE, Scatterometer, Information Systems, Etc.	174.8	198.4	258.6	
TOTAL	1157.0	1404.5	1613.2	

FY 1985 OPERATING PLAN
OF THE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

(Millions of Dollars)

	FY 1985 January Budget	FY 1985 Operating Plan
RESEARCH AND DEVELOPMENT	2400.1	2422.6
Space Station	150.0	150.0
Space Transportation Capability Development	361.4	351.4
Physics and Astronomy	677.2	677.2
Life Sciences	63.3	62.3
Planetary Exploration	286.9	290.9
Space Applications	344.1	374.1
Technology Utilization	9.5	9.5
Commercial Use of Space	(---)	(8.5)
Aeronautical Research and Technology	342.4	342.4
Space Research and Technology	150.0	150.0
Tracking and Data Advanced Systems	15.3	14.8
SPACE FLIGHT CONTROL AND DATA COMMUNICATIONS	3600.3	3601.8
Shuttle Prod. and Operational Capability	1465.6	1492.1
Space Transportation Operations	1339.0	1314.0
Space and Ground Network, Comm. and Data Sys.	795.7	795.7
RESEARCH AND PROGRAM MANAGEMENT	1331.0	1336.3
CONSTRUCTION OF FACILITIES	160.0	150.0
TOTAL NASA	7491.4	7510.7

National Aeronautics and Space Administration

APPROXIMATE EFFECTS OF INFLATION
FY 1986 BUDGET
(millions of dollars)

TOTAL NASA	FY 1978	FY 1980	FY 1982	FY 1984	FY 1985	FY 1986	8-Year Change
Actual Budget Authority	4,063	5,243	6,020	7,248	7,511	7,886	+94%
Inflation Adjustment Budget Authority in Terms of Constant FY 1978 Dollars	4,063	4,326	4,092	4,387	4,367	4,391	+8%
Annual Rate 1978-1984 based on NASA Experience Which Reflects Labor Intensive Nature of NASA Program, 1985-1986 GNP Deflator Forecast		10.7	9.4	5.9	3.8 –	4.4	

ECONOMIC BENEFITS OF NASA PROGRAMS

O EMPLOYMENT:

PRIVATE SECTOR EMPLOYMENT	NASA EMPLOYED CIVIL SERVANTS	TOTAL
133 thousand	21,800	155 thousand

- NASA SPENDING IS HIGHLY LABOR INTENSIVE
- PRODUCTIVE HIGH-TECHNOLOGY EMPLOYMENT OPPORTUNITIES
- ASSUMING A MULTIPLIER EFFECT OF 2.5 -- NASA EXPENDITURES WILL RESULT IN ABOUT 390 THOUSAND JOBS IN FY 1986

O TECHNOLOGY TRANSFER/NEW PRODUCTS

- STUDIES INDICATE THAT EXPENDITURES ON NASA TYPE ACTIVITIES RESULT IN ECONOMIC GROWTH OF SEVERAL TIMES THE AMOUNT INVESTED
- NEW PRODUCTS AND CAPABILITIES

O BALANCE OF TRADE

- EXPORTS IN THE AEROSPACE SECTOR EXCEEDED IMPORTS BY MORE THAN $10 BILLION IN 1984
- PROJECTED AT ABOUT $14 BILLION FOR 1985

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1986 BUDGET MULT-YEAR ESTIMATES
(Millions of Dollars)

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
AGENCY TOTALS						
Space Transportation System	3,902	4,022	3,886	4,081	4,999	5,277
Space Science and Applications and Technology	2,022	2,265	2,357	2,417	2,406	2,524
Supporting Space Activities	954	977	990	996	1,007	1,038
Air Transportation	633	622	647	667	684	697
Total	7,511	7,886	7,880	8,161	9,096	9,536

National Aeronautics and Space Administration

FY 1986 BUDGET ESTIMATES
RESEARCH AND DEVELOPMENT
(millions of dollars)

	FY 1984	FY 1985	FY 1986
SPACE STATION	(21.9)*	150.0	230.0
System Definition	(5.5)	52.0	74.0
Technology and Management Integration	(16.4)	98.0	156.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	431.7	351.4	459.3
Spacelab	111.0	58.3	96.7
Upper Stages	143.2	92.4	122.0
Engineering and Technical Base	93.1	105.7	109.7
Payload Operations and Support Equipment	59.6	56.3	63.9
Advanced Programs	21.5	20.5	21.0
Tethered Satellite	3.3	18.2	21.0
Orbital Maneuvering Vehicle	---	---	25.0

*In FY 1984, funded as part of the Office of Space Fight ($13.0 million), Office of Aeronautics and Space Technology ($6.0 million), Office of Space Science and Applications ($2.0 million), and Office of Space Tracking and Data Systems ($0.9 million).

National Aeronautics and Space Administration

FY 1986 BUDGET ESTIMATES
RESEARCH AND DEVELOPMENT
(millions of dollars)

	FY 1984	FY 1985	FY 1986	Total Project Cost Estimate
SPACE SCIENCE & APPLICATIONS	1157.0	1404.5	1613.2	
Physics and Astronomy	567.6	677.2	630.4	
Hubble space telescope development	195.6	195.0	127.8	1175
Gamma ray observatory development	85.9	117.2	87.3	(425-475)
Shuttle/Spacelab payloads development and mission management	80.9	105.4	135.5	
Explorer development	48.7	51.9	55.2	
Mission operations and data analysis	68.1	109.1	119.9	
Research and analysis	35.9	39.9	42.3	
Suborbital program	52.5	58.7	62.4	
Life Sciences	58.0	62.3	72.0	
Flight experiments	23.0	27.1	33.4	
Research and analysis	35.0	35.2	38.6	
Planetary Exploration	217.4	290.9	359.0	
Galileo development	79.5	56.1	39.7	(830-910)
Ulysses	6.0	9.0	5.6	(140-170)
Venus radar mapper mission	29.0	92.5	112.0	(350-400)
Mars observer	---	13.0	43.8	(300-375)
Mission operations and data analysis	43.4	58.8	95.0	
Research and analysis	59.5	61.5	62.9	
Solid Earth Observations	76.4	57.6	74.9	
Landsat-4	16.8	---	---	(500-510)
Shuttle/Spacelab payloads	17.0	12.1	23.1	
Geodynamics	28.0	29.9	31.7	
Research and analysis	14.6	15.6	20.1	

National Aeronautics and Space Administration

FY 1986 BUDGET ESTIMATES
RESEARCH AND DEVELOPMENT
(millions of dollars)

	FY 1984	FY 1985	FY 1986	Total Project Cost Estimate
Environmental Observations	162.0	212.7	317.5	
Upper atmosphere research and analysis	28.4	31.0	33.0	
Atmospheric dynamics/radiation research and analysis	27.5	28.5	30.3	
Oceanic process research and analysis	18.2	19.4	20.6	
Space physics research and analysis	16.8	16.7	17.8	
Shuttle/Spacelab development payload	7.6	7.8	5.6	
Operational satellite improvement program	0.6	---	---	
Earth radiation budget experiment	15.5	8.1	2.0	(110-130)
Extended mission operations	27.4	29.5	37.0	
Interdisciplinary research and analysis	---	1.0	1.0	
Tethered satellite payloads	---	3.0	4.5	
Scatterometer	---	12.0	31.7	(120-135)
Upper atmosphere research satellite mission	20.0	55.7	134.0	(630-700)
Materials Processing	25.6	27.0	34.0	
Communications	41.1	60.6	106.2	
Advanced communications technology satellite	25.0	45.0	90.0	(325-425)
Communications research and analysis	8.5	9.1	10.6	
Search and rescue	3.8	2.4	1.3	
Technical consultation and support studies	2.7	2.9	3.1	
Experiment coordination and operations support	1.1	1.2	1.2	
Information Systems	8.9	16.2	19.2	
TECHNOLOGY UTILIZATION	9.0	9.5	11.1	
COMMERCIAL USE OF SPACE	---	(8.5)*	30.0	

*In FY 1985, funded as part of the Office of Space Station ($0.2 million), Office of Space Flight ($4.5 million), Office of Space Science and Applications ($2.0 million), Office of Aeronautics and Space Technology ($0.7 million), and Office of Space Tracking and data Systems ($1.1 million).

National Aeronautics and Space Administration

FY 1986 BUDGET ESTIMATES
RESEARCH AND DEVELOPMENT
(millions of dollars)

	FY 1984	FY 1985	FY 1986
AERONAUTICAL RESEARCH AND TECHNOLOGY	315.3	342.4	354.0
Research and Technology Base	228.5	223.3	239.3
Systems Technology Programs	86.8	119.1	114.7
Rotorcraft systems	27.9	26.0	20.5
Guidance and navigation	(1.6)	(---)	(---)
Rotor systems research aircraft flight research/rotors	(3.3)	(---)	(---)
Advanced rotorcraft technology	(14.7)	(9.7)	(2.7)
Technology for next generation rotorcraft	(8.3)	(16.3)	(17.8)
High-performance aircraft systems	19.9	21.5	21.8
High-performance flight research	(8.7)	(9.7)	(9.8)
Turbine engine hot section technology	(11.2)	(9.3)	(5.2)
Ceramics for turbine engines	(---)	(2.5)	(2.1)
Oblique wing technology	(---)	(---)	(4.7)
Subsonic aircraft systems	5.0	19.0	---
Advanced composite structures	(5.0)	(19.0)	(---)
Advanced propulsion systems	17.0	26.1	44.2
Advanced turboprop systems	(15.0)	(24.0)	(42.0)
General aviation/commuter engine	(2.0)	(2.1)	(2.2)
Numerical aerodynamic simulation	17.0	26.5	28.2

National Aeronautics and Space Administration

FY 1986 BUDGET ESTIMATES
RESEARCH AND DEVELOPMENT
(millions of dollars)

	FY 1984	FY 1985	FY 1986
SPACE RESEARCH AND TECHNOLOGY	137.0	150.0	168.0
Research and Technology Base	124.9	136.3	140.0
Systems Technology Programs	7.5	8.8	20.0
Space flight experiments	6.3	5.4	6.2
Long duration exposure facility	0.7	0.7	---
Ion auxiliary propulsion system	0.5	0.6	---
Chemical propulsion systems technology	---	2.1	5.8
Control of flexible structures flight experiment	---	---	5.0
Orbital transfer vehicle technologies	---	---	3.0
Standards and Practices	4.6	4.9	8.0
TRACKING AND DATA ADVANCED SYSTEMS	14.2	14.8	16.2
TOTAL RESEARCH AND DEVELOPMENT	2064.2	2422.6	2881.8

National Aeronautics and Space Administration

FY 1986 BUDGET ESTIMATES
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS
(millions of dollars)

	FY 1984	FY 1985	FY 1986
SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	1646.3	1492.1	976.5
Orbiter	724.9	655.3	333.6
Launch and Mission Support	277.7	229.8	163.9
Propulsion Systems	638.2	582.0	454.0
Changes and Systems Upgrading	5.5	25.0	25.0
SPACE TRANSPORTATION OPERATIONS	1452.0	1314.0	1725.1
Shuttle Operations	1402.0	1314.0	1725.1
Flight operations	343.3	315.2	425.2
Flight hardware	729.5	722.9	964.0
Launch and landing operations	329.2	275.9	335.9
Expendable Launch Vehicles	50.0	---	---
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	674.0	795.7	808.3
Space Network	259.1	378.3	400.8
Ground Network	249.3	233.2	219.3
Communications and Data Systems	165.6	184.2	188.2
TOTAL SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	3772.3	3601.8	3509.9

National Aeronautics and Space Administration

CONSTRUCTION OF FACILITIES
SUMMARY

	FY 1986 (thousands of dollars)
AMES RESEARCH CENTER	8,200
o Construction of Numerical Aerodynamic Simulation Facility	8,200
GODDARD SPACE FLIGHT CENTER	11,800
o Construction of Addition to Research Projects Laboratory	3,800
o Construction of Spacecraft Systems Development and Integration Facility	8,000
JET PROPULSION LABORATORY	8,900
o Construction of Microdevices Laboratory	8,900
LANGLEY RESEARCH CENTER	4,900
o Modifications to 16-Foot Transonic Tunnel for Improved Productivity and Research Capability	4,900
SPACE TRANSPORTATION FACILITIES AT VARIOUS LOCATIONS	29,900
o Construction of Orbiter Modification and Refurbishment Facility (KSC)	14,000
o Construction of Thermal Protection System Facility (KSC)	3,600
o Modifications for Advanced Technology Engine Test Stand S-1C (MSFC)	6,500
o Modifications for Enhanced Life Support Systems Testing (JSC)	1,100
o Modifications to PAD A Payload Change-Out Room (KSC)	2,200
o Modifications to Space Shuttle Main Engine Support Systems (NSTL)	2,500
SPACE SHUTTLE PAYLOAD FACILITIES AT VARIOUS LOCATIONS	1,200
o Construction of Payload Control Rooms (KSC)	1,200
VARIOUS LOCATIONS	17,400
o Modification of 64-Meter Antenna, Goldstone, CA (JPL)	8,500
o Modification of 64-Meter Antenna, Canberra, Australia (JPL)	8,900
REPAIR OF FACILITIES AT VARIOUS LOCATIONS, NOT IN EXCESS OF $750,000 PER PROJECT	22,000

REHABILITATION AND MODIFICATION OF FACILITIES AT VARIOUS LOCATIONS, NOT IN EXCESS OF $750,000 PER PROJECT	27,000
MINOR CONSTRUCTION OF NEW FACILITES AND ADDITIONS TO EXISTING FACILITIES AT VARIOUS LOCATIONS, NOT IN EXCESS OF $500,000 PER PROJECT	6,000
FACILITY PLANNING AND DESIGN	12,000
TOTAL CONSTRUCTION OF FACILITIES	**149,300**

National Aeronautics and Space Administration

RESEARCH AND PROGRAM MANAGEMENT
DISTRIBUTION OF PERMANENT CIVIL SERVICE WORKYEARS BY INSTALLATION

	FY 1984	FY 1985	FY 1986
Johnson Space Center	3,196	3,222	3,201
Kennedy Space Center	2,074	2,075	2,054
Marshall Space Flight Center	3,270	3,251	3,229
National Space Technology Laboratories	107	109	106
Goddard Space Flight Center	3,608	3,599	3,569
Ames Research Center	2,023	2,021	2,001
Langley Research Center	2,869	2,860	2,808
Lewis Research Center	2,634	2,604	2,582
Headquarters	1,327	1,326	1,292
Inspector General	90	97	97
Subtotal, Full-Time Permanent Civil Service	21,198	21,164	20,939
Other than full-time permanent workyears	882	836	861
Total, Ceiling Controlled Civil Service	22,080	22,000	21,800

SUMMARY OF BUDGET PLAN BY INSTALLATION
(Thousands of Dollars)

	FY 1984	FY 1985	FY 1986
Johnson Space Center	200,963	211,978	213,713
Kennedy Space Center	172,632	181,980	189,331
Marshall Space Flight Center	189,852	197,576	195,805
National Space Technology Laboratories	10,194	10,940	11,131
Goddard Space Flight Center	186,773	199,482	199,719
Ames Research Center	113,887	121,527	123,908
Langley Research Center	139,953	148,731	149,059
Lewis Research Center	128,704	139,258	139,896
Headquarters	108,216	118,950	116,835
Inspector General	4,734	5,878	5,603
Total	1,255,908	1,336,300*	1,345,000

*Includes $23.3 million for a proposed pay raise supplemental offset by a proposed rescission of $4.0 million related to the 1984 Deficit Reduction Act.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

SPACE STATION

- Establish a permanently manned space station:
  - The next logical step in U.S. leadership in space
  - Built upon the operational capabilities of the Space Shuttle
  - Conducive to user community
  - Orbital activities begin in the next decade
- Perform a thoroughly detailed front-end definition including:
  - Engineering design by industrial contractors
  - Subsystem advanced development and tests in dedicated test beds
  - Early flight experiments on the Space Shuttle to prove system feasibility
  - Continued trade studies for system optimization
- Develop a multi-purpose facility involving both manned and unmanned elements to perform:
  - Essential scientific and technical research
  - Unique commercial activities
  - Operational tasks in space more efficiently such as:
    - Satellite servicing
    - Assembly and servicing of platforms
    - Placement of spacecraft into higher orbits
  - Extensive national and international user community participation through:
    - Simplified user interfaces
    - Capability for on-orbit crew maintenance
    - Operational autonomy to achieve effective long-term performance
  - Staging base for potential future national programs such as:
    - Manned missions to the Moon or planets
    - Unmanned scientific probes and sample returns

MAJOR FLIGHT ACTIVITY

	Fiscal Years					
	1985	1986	1987	1988	1989	1990
Flight Experiments on Space Shuttle....................		Δ				

BUDGET PLAN (millions of dollars)	FY 1984	FY 1985	FY 1986
Utilization	(4.1)	9.0	15.0
Advanced Development	(6.9)	52.3	82.0
Systems Definition	(5.5)	52.0	74.0
Operation Readiness	(---)	3.0	7.0
Program Management Integration	(5.4)	33.7	52.0
Systems Development	(---)	---	---
Total	(21.9)*	150.0	230.0

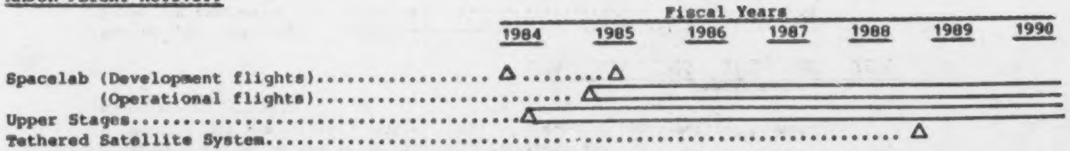
*Funded as part of the Office of Space Fight ($13.0), Office of Aeronautics and Space Technology ($6.0), Office of Space Science and Applications ($2.0), and Office of Tracking and Data Systems ($0.9) FY 1984 budgets.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT

- o Proceed with development of the capabilities to enhance the space transporation system through pursuit of:
  - Manned orbital experiments using Shuttle and Spacelab
  - Complete development of Centaur upper stage to place payloads into deep space and in geosynchronous orbits
  - Identification of future space programs and new technology to reduce program risks
  - Orbital placement, servicing and retrieval of automated satellites
  - Orbital maneuvering vehicle to extend operational on-orbit capabilities range
- o Development of United States-Italian Tethered Satellite System
- o Maintain engineering, scientific and technical support capability
- o Development of operational equipment to support payload pre- and post-launch processing and on-orbit operations

MAJOR FLIGHT ACTIVITY



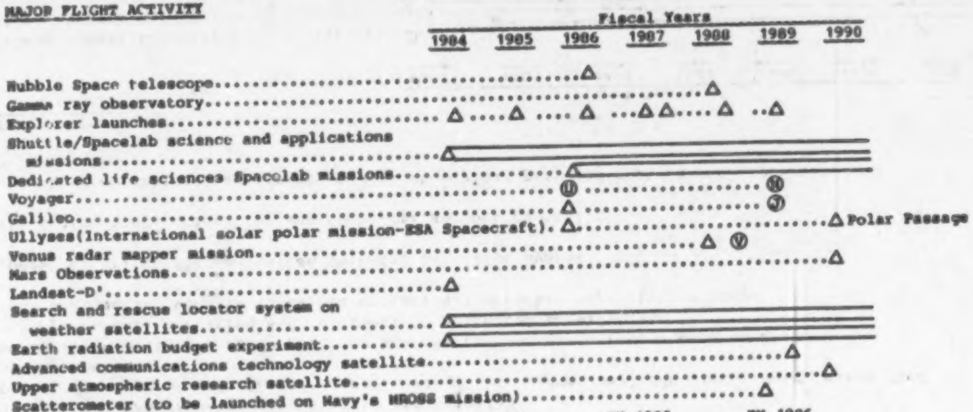
BUDGET PLAN (millions of dollars)	FY 1984	FY 1985	FY 1986
Space Transportation Capability Development	431.7	351.4	459.3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

SPACE SCIENCE AND APPLICATIONS

- Increase our understanding of the Earth and its environment, the solar system, and the universe through a balanced program of space exploration missions and ground-based investigations;
- Utilize the space environment for research in the biomedical, biological, and bioinstrumentation fields;
- Exploit the knowledge gained from current and completed program efforts by thorough analysis and interpretation of the scientific data obtained; and
- Develop and demonstrate practical uses of space and space-derived technology

MAJOR FLIGHT ACTIVITY



BUDGET PLAN (millions of dollars)	FY 1984	FY 1985	FY 1986
Physics and Astronomy	567.6	677.2	630.4
Life Sciences	58.0	62.3	72.0
Planetary Exploration	217.4	290.9	359.0
Solid Earth Observations	76.4	57.6	74.9
Environmental Observations	162.0	212.7	317.5
Materials Processing in Space	25.6	27.0	34.0
Communications	41.1	60.6	106.2
Information Systems	8.9	16.2	19.2
Total Space Science and Applications	1157.0	1404.5	1613.2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

AERONAUTICAL RESEARCH AND TECHNOLOGY

- Conduct the fundamental research and technology in the aeronautical disciplines and systems research applicable to general classes of advanced civil and military aircraft to:
  - Improve performance
  - Reduce costs
  - Increase safety
  - Reduce energy requirements
  - Decrease environmental effects

- Develop and sustain a strong Research and Technology Base in:
  - Fluid and thermal physics
  - Applied aerodynamics
  - Materials and structures
  - Controls and guidance
  - Human factors
  - Information sciences
  - Propulsion and power
  - Flight systems
  - Systems analysis

- Conduct focused systems technology to evaluate the technical feasibility of advances or concepts:
  - Numerical aerodynamic simulation for complex aerospace computational problems
  - Technology for next generation rotorcraft including X-Wing and advanced tilt-rotor technology
  - Turbine engine hot section technology for higher performance and longer lasting engines
  - High-performance flight research
  - Advanced rotorcraft technology and flight research
  - General aviation/commuter engine technology for better performance and efficiencies
  - Advanced turboprop systems for faster, more fuel-efficient transport and commuter aircraft
  - Ceramics for turbine engines for high operating temperatures
  - Oblique wing technology for aerodynamic efficiency over transonic speeds

- Maintain expertise and operate significant national facilities to support research and technology:
  - Research and test facilities
  - Simulation facilities
  - Wind tunnels

BUDGET PLAN (millions of dollars)	FY 1984	FY 1985	FY 1986
Aeronautical Research and Technology	315.3	342.4	354.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

SPACE RESEARCH AND TECHNOLOGY

o Provide a technology base essential to future United States leadership in space by:

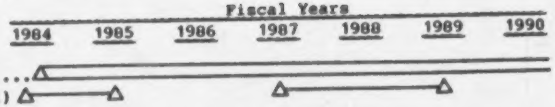
- Improving performance and effectiveness
- Reducing cost and risk
- Increasing reliability
- Developing technological options

o Achieve these objectives, by means of ground and space-based research and technology activities, through advances in the technology areas of:

- Aerothermodynamics
- Materials and structures
- Space energy conversion
- Propulsion
- Space data and communications
- Information sciences
- Controls and guidance
- Human factors
- Space flight systems
- Systems analysis

MAJOR FLIGHT ACTIVITY

Space technology Shuttle/Spacelab payloads..........
Long duration exposure facility (Launch/Retrieval)



BUDGET PLAN (millions of dollars)	FY 1984	FY 1985	FY 1986
Space Research and Technology	137.0	150.0	168.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY/SPACE TRANSPORTATION OPERATIONS

- Continue with the operational establishment of a versatile and cost-effective space transportation system to provide for:
  - Completing and operating a national fleet of four Space Shuttle orbiters
  - Ground support equipment, launch site equipment and manpower to support launch and landing operations
  - External tanks and solid rocket boosters and the manufacturing tooling/equipment supporting their production
  - Establishing logistics support capability to provision spares, repair and overhaul flight hardware
  - Provision of capability for training astronauts, launch and flight operation personnel
- Thirteen to fourteen operational flight missions in FY 1986 building to a flight rate of 24 per year by FY 1989
- Continued improvement of Shuttle performance capability
- Support to first Vanderburg Air Force Base flight
- Implementation of improvements to make space transportation more economical and cost effective to all users

MAJOR FLIGHT ACTIVITY

	Fiscal Years						
	1984	1985	1986	1987	1988	1989	1990
Space Shuttle: Operational flights	4	10	14	17	19	24	24

BUDGET PLAN (millions of dollars)

	FY 1984	FY 1985	FY 1986
Shuttle Production and Operational Capability	1,646.3	1,492.1	976.5
Space Transportation Operations	1,452.0	1,314.0	1,725.1
	3,098.3	2,806.1	2,701.6

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

SPACE AND GROUND NETWORKS, COMMUNICATION AND DATA SYSTEMS

o Tracking and Data Acquisition using Space and Ground Network interconnected with highly reliable communications to provide support to:

- Shuttle operational flights
- Automated Earth orbiting missions - supports applications and scientific spacecraft including the Nimbus, Landsat, International Ultraviolet Explorer, International Sun-Earth Explorer, Applications Technology Satellites, Solar Maximum Mission, Dynamics Explorer, Solar Mesosphere Explorer, Earth Radiation Budget Satellite, and Active Magnetospheric Particle Tracer Explorer.
- Planetary missions - support will continue for Pioneers-10 and -11, Pioneer Venus, and Voyagers-1 and -2, as well as limited support for Helios and earlier Pioneer missions
- Upcoming missions which will include Space Telescope, Galileo and Ulysses
- Sounding rockets
- Aeronautical flight research program

o The Tracking and Data Relay Satellite System (TDRSS) will replace most ground stations in providing tracking, command and telemetry services to all low-Earth orbital missions. The first spacecraft was launched in April 1983, the second is scheduled to be launched in February 1985 and the third launch is planned for the last half of 1985.

MAJOR FLIGHT ACTIVITY	Fiscal Years						
	1984	1985	1986	1987	1988	1989	1990
Tracking and Data Relay Satellite......................... (Backup satellites available)		Δ Δ					

BUDGET PLAN (millions of dollars)	FY 1984	FY 1985	FY 1986
Space & Ground Network, Comm., and Data Systems	674.0	795.7	808.3

National Aeronautics and Space Administration

BENEFITS OF NASA PROGRAMS

- Tangible effects on the economy through creation of productive high-technology employment opportunities nationwide

- Intangible benefits realized through exploration of challenging and stimulating new frontiers

- Major contributions to maintaining the nation's competitive position in high technology and aeronautical research
  - Technology advances in high-speed aircraft and advanced rotorcraft
  - Wind tunnel testing of new aircraft developments
  - Improvements in communications, weather and remote sensing satellite systems

- Continuing advances in space applications, science and technology research operations in Space using the Shuttle, Spacelab and Space Station
  - Shirt-sleeve laboratory environment for life sciences, materials processing, astrophysics, and Earth observations
  - Transportation and servicing of very large and complex observatories and orbiting platforms
  - Achieving economies in space operations through retrieval and repair of spacecraft
  - Advances in robotics and automation technology through space station development

- Practical applications of space technology through NASA programs and by the private sector
  - Resource observations and identification for mapping and geological exploration
  - Environmental observations and monitoring for long term trend analysis of global atmospheric patterns
  - Space and ground communications systems including leadership in the Search and Rescue program
  - Use of space-derived technology in health and medicine, such as biotelemetry for motion analysis and implantable monitoring devices
  - Advances in construction methodology and techniques using new composite materials, coatings, and insulation materials

- Improvements in aviation safety, efficiency and environmental acceptability through NASA's aeronautical research and application of NASA's technologies to improve passenger protection and engine efficiency

- Fostering international cooperation by involvement in various NASA programs of other nations

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1986 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION
(Millions of Dollars)

	Total			Space Flight Control and Data Communications			Research and Development			Construction of Facilities			Research and Program Management		
	1984	1985	1986	1984	1985	1986	1984	1985	1986	1984	1985	1986	1984	1985	1986
Johnson Space Center........	1,682,496	1,572,781	1,417,605	1,303,210	1,124,450	910,100	175,849	233,153	292,692	2,300	3,200	1,100	201,137	211,978	213,713
Kennedy Space Center........	724,090	631,499	659,691	439,900	372,900	375,500	53,008	47,019	73,860	58,550	29,600	21,000	172,632	181,980	189,331
Marshall Space Flight Center	1,921,564	1,915,382	1,962,795	1,272,900	1,224,400	1,273,800	447,112	491,806	506,690	11,700	1,600	6,500	189,852	197,576	175,805
National Space Technology Laboratories..............	20,549	31,691	32,253	800	6,300	7,200	9,555	11,451	11,422	---	3,000	2,500	10,194	10,940	11,131
Goddard Space Flight Center.	950,607	1,020,099	1,088,496	405,916	420,030	366,100	357,918	398,387	510,877	---	2,200	11,800	186,773	199,482	199,719
Jet Propulsion Laboratory...	349,824	469,616	602,356	97,189	109,500	124,800	248,335	347,916	468,656	4,300	12,200	8,900	---	---	---
Ames Research Center.........	318,057	400,672	386,284	9,800	11,200	14,100	189,670	254,145	240,076	4,700	13,800	8,200	113,887	121,527	123,908
Langley Research Center.....	289,760	336,605	324,325	200	100	100	140,107	173,974	170,266	9,500	13,800	4,900	139,953	148,731	149,059
Lewis Research Center.......	423,233	405,362	520,806	2,000	20	---	281,929	266,084	380,910	10,600	---	---	128,704	139,258	139,896
Inspector General............	4,734	5,878	5,603	---	---	---	---	---	---	---	---	---	4,734	5,878	5,603
Headquarters................	553,118	687,515	836,386	240,385	324,900	438,200	160,717	198,665	226,351	43,800	45,000	55,000	108,216	118,950	116,835
Undistributed Construction of Facilities:															
Various Locations..........	1,450	13,800	17,400	---	---	---	---	---	---	1,450	13,800	17,400	---	---	---
Facility Planning and Design............ ..	8,600	12,000	12,000	---	---	---	---	---	---	8,600	12,000	12,000	---	---	---
Total Budget Plan........	7,248,082	7,510,700	7,886,000	3,772,300	3,601,800	3,509,900	2,064,200	2,422,600	2,881,800	155,500	150,000	149,300	1,256,082	1,338,300	1,165,000

National Aeronautics and Space Administration

FY 1986
MAJOR ACTIVITIES BY CENTER

AMES RESEARCH CENTER/DRYDEN FLIGHT RESEARCH FACILITY

- Theoretical and experimental aerodynamics, fluid and thermal physics
- Rotorcraft technology, low-speed vehicle systems, computational fluid dynamics, aeronautical flight research, flight test techniques, flight instrumentation development, short takeoff and vertical landing technology
- Aircraft flight simulation, flight research evaluation
- Human-vehicle interactions
- Structure response to aerodynamic heating
- Numerical aerodynamic simulation capability
- Entry technology, materials research, project support (e.g., Shuttle, OEX, Galileo probe, infrared astronomy)
- Life sciences (biomedical support systems, space biology research, non-human biological experiments)
- Atmospheric physics and astrophysics, astronomy and infrared astronomy research (Shuttle Infrared Telescope Facility definition)
- Galileo probe project management
- Airborne research and applications experiments
- Planetary mission operations and data analysis
- Shuttle contingency landing site at Dryden Flight Research Facility
- Earth and environmental observations (space, atmospheric, and stratospheric programs), airborne platforms

GODDARD SPACE FLIGHT CENTER/WALLOPS FLIGHT FACILITY

- Development and management of Spacelab payloads
- Development of Earth orbital spacecraft and experiments for space applications and space science
- Sounding rocket and balloon development, procurement, launch and operations
- Aeronautical flight test support (Wallops)
- Experiment management support to environmental observations in weather and climate and ocean dynamics
- Physics and astronomy explorers
- Tracking and data acquisition - Tracking Network/Tracking and Data Relay Satellite
- Management of Delta launch vehicle program
- Mission management of special payloads
- Science instruments for Hubble Space Telescope and Hubble Space Telescope operations
- Gamma Ray observatory project management and science instruments
- Upper Atmospheric Research Satellite mission management
- Scientific research including both theoretical studies and experiment development
- Space Station definition and technology development

JET PROPULSION LABORATORY

- Planetary exploration development, management and operation of planetary spacecraft and experiments
- Galileo project management
- Voyager project operations including activities for Uranus and Neptune encounters
- Venus Radar Mapper project management
- Ulysses (previously ISPM) Mission instruments and support
- Mars Observer (previously MGCO) project management
- Tracking and data acquisition - operation of Deep Space Network
- Network consolidation - Spaceflight Tracking and Data Network and Deep Space Network
- Space and terrestrial energy research and technology
- Management of design and development activities for a Scatterometer to be flown on the Navy Remote Ocean Sensing System
- Extreme ultraviolet explorer mission project management

JOHNSON SPACE CENTER

- Overall Shuttle management
- Shuttle orbiter development, logistics and STS integration
- STS operations including capability development, planning and flight control
- STS crew equipment and crew training
- Designing, developing and testing spaceborne instruments to measure from space, phenomena on or above the Earth
- Life sciences flight experiment development, flight crew monitoring and physiological requirements for manned space systems
- Maintain lunar and planetary geosciences technical base
- Spacelab payload mission management for Spacelab 4
- Advanced concept studies for manned space flight
- Space Station lead center
- Space Station definition and technology development

KENNEDY SPACE CENTER

- Shuttle launch and landing operations and facilities
- Shuttle payload and cargo integration
- Spacelab integration
- Expendable launch vehicle operations
- Space Station definition and technology development

LANGLEY RESEARCH CENTER

- Transport aircraft technology
- Subsonic aircraft technology, fuel efficiency
- Aircraft materials and structures
- Theoretical and experimental aerodynamics
- General aviation engineering technology
- Space materials and structures
- Entry technology, technology experiments in space
- Advanced space vehicle configuration technology
- Space energy conversion basic research
- Electronic component technology, information systems, sensor research
- Environmental observations technology (atmospheric science, experiment development, space/ground/aircraft investigations)

LEWIS RESEARCH CENTER

- Aero propulsion systems, engine component technology, engine systems research
- Internal computational fluid dynamics, unsteady aerodynamics, and aeroelasticity
- Aircraft materials and structures
- Chemical and electric propulsion
- Space energy conversion; power generation
- Space data and communications
- Space materials and structures
- Advanced Communications Technology Satellite project management
- Develop microgravity experiments
- Space communications research
- STS/Centaur development and operation
- Atlas/Centaur launch vehicle management
- Space Station definition and technology development

MARSHALL SPACE FLIGHT CENTER

- Space Shuttle main engine, external tank, and solid rocket booster sustaining engineering capability and procurement activities
- Sustaining engineering for NASA elements of Spacelab (crew transfer tunnel, hardware mock-ups, crew trainer, etc.), procurement of Spacelab hardware from ESA, and development of related payload carriers

- Inertial upper stage support for non-DOD missions
- Hubble Space Telescope project management
- Materials-processing-in-space research and development
- Spacelab payload mission management for Spacelabs 1, 2, and 3
- Advanced concept studies for manned space flight
- Space structures and materials technology and propulsion technology support
- Tethered Satellite System project management for NASA elements (deployer development, systems engineering and integration)
- Technical monitoring of PAM upper stages
- Development of Orbital Maneuvering Vehicle systems
- Space Station definition and technology development

NATIONAL SPACE TECHNOLOGY LABORATORIES

- Acceptance testing of the Shuttle main engines
- Shuttle main propulsion test article development testing
- Remote sensing and environmental research
- Support of co-located tenant organizations

Mr. **Nelson**. OK. Thank you, Mr. Newman. Thank you very much.

On page 8 you made reference to those studies that show that the economic gross to the country is several times the amount that is invested through NASA. Can you put your hand on those studies fairly quickly and send me a copy?

Mr. **Newman**. Yes, we can do that.

Mr. **Nelson**. I'd appreciate that.

[Material to be supplied has been retained in committee files:] [2]

Mr. **Newman**. There was one by Midwest Research; there was one by Chase Econometrics; I think Denver Research Institute did one, also.

Mr. **Nelson**. OK. Any questions for Mr. Newman? Anybody on the committee? Any questions?

Mr. Newman, of course there is more and more pressure as you read the newspaper every day about a budget freeze. The Senate Budget Committee started working on that. I proposed such a freeze a year ago; it only got 108 votes in the House. It was a zero growth rate, so it was coming right across the board on everything, holding it at the level of inflation, approximately. There were some few little deviations.

Anyway, there's more and more consensus and talk about a budget freeze. There's talk about freezing it at fiscal year 1985 levels or freezing it at the CBO baseline for 1986. If the CBO baseline was used, there might be as much as a $400 million cut in NASA, and a lot of that depends on the economic assumptions that are made, so it's a rather imprecise kind of hypothetical that I'm giving you.

But if such a scenario developed here, what would a 1-year freeze do and how would you restructure your program priorities if you were given a $400 million cut?

Mr. **Newman**. I'd like to make several points here, if I may.

In the first place, if you talk about a freeze at the level of 1985 plus inflation, that would be very close to our present request.

Mr. **Nelson**. Yes.

Mr. **Newman**. We're up about 5 percent——

Mr. **Nelson**. And inflation is about 4 percent. You have a real growth of about 1 percent.

Mr. **Newman**. Actually, somewhat less than that.

Mr. **Nelson**. Really?

Mr. **Newman**. Well, the President's budget shows 4.4 percent as the inflation factor——

Mr. **Nelson**. He uses what?

Mr. **Newman**. He uses 4.4 percent.

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[2] (a) Economic Impact of NASA R&D Spending—Executive Summary, prepared for NASA by Michael K. Evans, Chase Econometric Associates, Inc., Bala Cynwyd, PA, April 1976.

(b) Quantifying the Benefits to the National Economy from Secondary Applications of NASA Technology—Executive Summary, prepared for NASA by Mathematica, Inc., Princeton, NJ, March 1976.

(c) Social Sciences and Space Exploration, prepared for NASA by Chesten, Chafer and Chafer, Georgetown University, Washington, DC, November 1984.

(d) Economic Impact of Stimulated Technological Activity, Part I—Overall Economic Impact of Technological Progress. its Measurement, prepared for NASA by Midwest Research Institute, 15 October 1971, Contract No. NASW-2030.

Mr. Nelson. Oh, 4.4 percent. So you're talking about six-tenths of 1 percent?

Mr. Newman. Yes, sir.

Mr. Nelson. OK.

Mr. Newman. Second the President's——

Mr. Nelson. So that wouldn't hurt you very much?

Mr. Newman. A cut to that level would be a relatively minor cut. If you take the current services figure in the President's budget, we're actually below that.

Mr. Nelson. Current services for 1986?

Mr. Newman. Yes, sir.

Mr. Nelson. From 1985?

Mr. Newman. Yes, sir.

Mr. Nelson. OK. How much are you below? Do you know those figures?

Mr. Newman. We're below it by about $30 million. It would be just over $7.9 billion.

Mr. Nelson. Now, are you talking now from your appropriations estimates, or are you talking from BA—budget authority?

Mr. Newman. Budget authority.

Mr. Nelson. OK. All right.

Mr. Newman. I'd also like to make the point that within this budget, we've absorbed a number of items that were not planned originally. Because of the cutback in the DOD missions and the fact that shuttle operational costs involve a larger element of fairly nonvariable costs, we could not make an adjustment in the flight rate that would total the offset, the change in the planning primarily of DOD, but also of foreign and commercial customers. We've had to increase our operations budget about $140 million over what we'd planned last year.

We also have put into our program the advanced communication technology satellite. You may remember last year, we proposed a ground test program. The Congress directed us to proceed with the flight program, and that cost requires about $90 million in fiscal 1986.

We have put into our budget the commercialization activities. That's about $30 million. We requested last year that the ceiling on the tracking and data communications satellite be increased so that we could continue payments in the normal manner. That request was not approved, and we had to make a front-end payment to help reduce the interest on that program, so we've had to include that in our budget.

So we have quite a few things in our budget that were not in the anticipated runout of last year.

Mr. Nelson. Let me ask you about TDRSS, since you brought that up. Since the TDRSS is not being launched this month, do you see an impact on the scheduled early repayment of that $30 million in fiscal year 1986 to the Federal Financing Bank?

Mr. Newman. No; the repayments are to the bank, not to the contractor as such. These are against loans that have been made under the previous authorization. I do not believe that would change our repayment schedule to the bank.

But we have these additional requirements, and the point I was making before getting to the direct answer is that we have had to do a number of things that we had not previously planned.

Now, if we were cut back in the magnitude that you talked about, we would really have to do a restructuring of the program. We would have to consider not doing some of those things that I just mentioned. We might come back and ask for approval of the increase in the TDRSS again; we might have to consider whether to proceed with the communications satellite development. We would also have to look at some cutbacks in the ongoing program. We really have not worked out that option. We would, I'd think, particularly if we were talking about a short-term cutback, we would have to reserve the capability to proceed with projects in the future—in other words, maintaining our capability to move out when the opportunity comes. That would be very important to us.

Mr. **Nelson**. So getting back to—if you had to load up on a $400 million cut, what in the world would you do? How would you restructure your program priorities?

Mr. **Newman**. Well, if I answered you in detail, I'd be prejudging decisions we haven't made. I think we'd have to consider cutting those things I mentioned back. We'd have to probably consider changing the space station schedule. We would have to look—I think we would preserve projects like Galileo and Space Telescope and those projects where we already have substantial investment and can realize the benefits where there would be relatively small savings compared to the benefits lost. We would have to look at the projects that are future projects, probably things like the Venus Radar Mapper, the Mars Orbiter, the Gamma Ray Observatory. Or we could make some adjustment in schedule, and we would have to look hard at preserving the capability to conduct those projects as time and funds permit.

Mr. **Nelson**. OK. Let me just ask you a couple more and then we're going to recess, because we'll be going over to vote.

How much of NASA's planning wedge is dependent on the receipts from the shuttle launches between now and 1989?

Mr. **Newman**. Well, let me answer it this way. Our total budget plan is based on the receipts in the kind of magnitude I told you. They build up to about $850 million in 1987, on up to $1.2 billion by 1989 and 1990. And to the extent that we fail to realize those receipts, we have the ability to cut back the missions and partially offset that. But since the payments that we receive from commercial customers exceed the marginal costs of those missions, we would have to absorb, I would say, about half of the loss of reimbursements. So if you take those figures of $1.2 billion by 1989 or 1990, and we were to lose all reimbursements altogether, it would obviously restructure the program; but you would have to say that about half of that amount would be the maximum possible jeopardy.

Mr. **Nelson**. OK. Before we recess, do you want to enlighten us a little bit on the future levels for NASA R&D? In your charts, you don't show much of the R&D portion in the appendix, as you project out. Do you want to share some thoughts with us?

Mr. **Newman**. Well, what we did in those was to show the functional categories that we have. Within that total, the research and development program as such—now, that includes the space station as well as the science and applications—that total would grow to about $3.4 billion in 1987 from the $2.881 billion in 1986. This is for the research and development appropriation, specifically. It grew to about $3.4 billion in 1987 and about $4 billion in 1988, and about $4.8 billion in 1989. What comes down is the space flight control and data communications because the shuttle production is phasing down, and the shuttle operations is benefiting more from the reimbursable receipts. I can give your staff a detail of that breakout if you want.

Mr. Nelson. OK. Please do.

[The information follows:]

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FISCAL YEAR 1986 BUDGET MULTIYEAR ESTIMATES

[In millions of dollars]

	Fiscal year—					
	1985	1986	1987	1988	1989	1990
Research and development:						
Space transportation system	501.4	709.3	1,184.7	1,725.7	2,563.4	2,765.4
Space science, applications and technology	1,564.0	,802.3	1,874.3	1,925.9	1,906.8	2,015.4
Supporting space activities	14.8	16.2	17.1	18.1	19.0	20.1
Air transportation	342.4	354.0	368.5	383.6	397.4	410.7
Total	2,422.6	2,881.8	3,444.6	4,053.3	4,886.6	5,211.6
Space flight, control and data communications:						
Space transportation system	2,806.1	2,701.6	2,085.4	1,727.3	1,790.6	1,850.2
Supporting space activities	795.7	808.3	833.0	837.4	850.8	880.2
Total	3,601.8	3,509.9	2,918.4	2,564.7	2,641.4	2,730.4
Research and program management:						
Space transportation system	563.1	581.2	590.9	603.0	614.5	626.6
Space science, applications and technology	449.0	449.6	462.3	471.0	479.5	488.3
Supporting space activities	58.6	59.2	57.9	59.0	60.0	61.1
Air transportation	265.6	255.0	259.0	263.0	267.0	271.0
Total	1,336.3	1,345.0	1,370.1	1,396.0	1,421.0	1,447.0
Construction of facilities:						
Space transportation system	31.2	29.9	25.0	25.0	30.0	35.0
Space science, applications and technology	8.3	13.0	20.0	20.0	20.0	20.0
Supporting space activities	85.2	93.3	82.0	82.0	77.0	77.0
Air transportation	25.3	13.1	20.0	20.0	20.0	15.0
Total	150.0	149.3	147.0	147.0	147.0	147.0
Agency totals:						
Space transportation system	3,901.8	4,022.0	3,886.0	4,081.0	4,998.5	5,277.2
Space science, applications and technology	2,021.3	2,264.9	2,356.6	2,416.9	2,406.3	2,523.7
Supporting space activities	954.3	977.0	990.0	996.5	1,006.8	1,038.4
Air transportation	633.3	622.1	647.5	666.6	684.4	696.7
Total	7,510.7	7,886.0	7,880.1	8,161.0	9,096.0	9,536.0

Mr. Nelson. One final question. Look on page——

Mr. Newman. Could I just add one more thing?

Mr. Nelson. Sure.

Mr. Newman. Our planning still provides to hold the Science Program within that at close—at least 20 percent of the total of those appropriations, fairly close to——

Mr. Nelson. Of the total budget?

Mr. Newman. Of the total for those two appropriations, research and development and space flight control.

Mr. Nelson. Whereas it's 25 percent now?

Mr. Newman. It's 25 percent now. And the base against which that would be measured would build up considerable because of the space station. The dollar figures would be fairly favorable to the Science Program.

Mr. Nelson. OK.

Please look on page 2, your column for fiscal year 1986. Now, your total BA is $7.886 billion, but your outlays are $7.772 billion.

Mr. Newman. Yes, sir.

Mr. Nelson. All right. Now, why? How can you project that that's what your actual outlays are going to be from your BA?

Mr. Newman. Well, budget authority, of course—when you receive that, you then have to obligate it and the costs have to occur before the outlays occur. There's a lag time in that. And as you can see, with a—if you look at the 3 years as a whole, you'll see the budget authority growing from $7.2 billion to that $7.886 billion. You'll see the outlays building up but lagging behind.

Mr. Nelson. Yes.

Mr. Newman. And you'll always have that situation in a program where the dollar figures are increasing. The outlays don't occur as rapidly as——

Mr. Nelson. Yes, I understand that, but you feel confident enough that you can actually project that if you got $7.886 billion of BA on the basis of what you got also in the last several years, you're pretty accurate that you would actually outlay $7.772 billion?

Mr. Newman. Close to that. Over the years, we've come quite close to our outlays.

Mr. Nelson. All right. The committee will stand in recess until after the vote.

And Mr. Newman, if you want to leave, we'll take the next witness. They didn't have any more questions.

[Recess taken.]

Mr. Gordon. Mr. Hosenball, I appreciate your courtesy. We do have to vote every now and then here, and you're very patient. If you will proceed with your testimony, and I understand you're going to summarize that for us?

Mr. Hosenball. Yes, I understand the committee is pressed for time.

STATEMENT OF S. NEIL HOSENBALL, GENERAL COUNSEL, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Hosenball. There are two rather straightforward substantive changes that we're recommending to the Space Act. One is to facilitate our IG office's responsibilities by giving them the authority to administer oaths when they do their investigations. That authority has been given to most of the departments, and a lot of the agencies have that authority independently in one way or another. They require it, and so we are proposing it and hopefully the committee will approve that legislation.

The second is an amendment to the patent to our Space Act which, in effect, would extend the patent laws to space vehicles. It would cover the shuttle, it would cover free-flying platforms, and it will cover the space station, ultimately. And the reason we have suggested that is that patent laws are only subject to the territory that they apply to. They have no extraterritoriality at all; they are governed by patent treaties, which most nations belong to, and since there is no sovereignty in space by treaty—you can't claim sovereignty—we thought it would be necessary to extend the patent laws because there is a great deal of experimentation going on on the shuttle, and certainly would be more so, even for the Space Station.

And those, basically, are the two provisions we've suggested. While there hasn't been a problem so far in the patent area, Mr. Beggs has testified many times—and I agree with him—that we are experimenting; you'll be doing in space—a lot of new inventions came about purely through accident, and that's just liable to happen in space, as well. And that's why we're proposing it at this time.

And that pretty much summarizes what we have recommended.

[The prepared statement of Mr. Hosenball follows:]

March 6, 1985

Statement of

S. Neil Hosenball
General Counsel

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

It is my pleasure to be here once again to testify on the legal changes that NASA is proposing in this year's authorization bill. There are two.

The first is section 7 which would provide the NASA Office of Inspector General (OIG) staff with statutory oath administration authority during the course of OIG investigations and audits. At the present time OIG auditors and investigators lack the authority to administer oaths during investigative interviews or when doing audits. When sworn statements are needed, it is necessary to obtain the services of a duly empowered notary public. This is often cumbersome, particularly when the course of an investigation crosses state lines. Yet, the solemnity of an oath is often conducive to truthful inquiries, especially where the oath-takers are government agents who understand its meaning. The alternative, unsworn statements, may lead to inaccurate statements or subsequent changes in testimony, harmful not only to the fact-finding process but also to the due process rights of individuals under inquiry.

The NASA OIG staff is one of the few within the executive branch which lacks this authority. Inspector General organizations in the executive departments have authority to administer oaths while investigating fraud or misconduct per 5 U.S.C. 303(a). Some independent agencies have oath administration powers in their statutes; these include the General Services Administration, the Small Business Administration and the Veterans Administration.

This provision would give to the NASA Office of Inspector General staff an oath administration authority similar to that enjoyed by a majority of the Offices of Inspector General in the executive branch, and we urge its inclusion in this year's bill.

The second change is found in section 8. This is an amendment to the patent section of the Space Act which would provide that any invention made or used in outer space on a space vehicle under the jurisdiction or control of the United States shall be considered made or used in the United States for the purposes of patent law (title 35 of the United States Code). This gives the United States "jurisdiction" over inventions made or used in space which are on satellites, platforms, other orbiting vehicles, manned or unmanned, together with related equipment, devices, components and parts under U.S. control. This is important in determining the priority of invention, rights to inventions made with U.S. government funds, and enforcement of privately held patents against infringers. This amendment provides certainty for inventions made or used in space under U.S. control and is consistent with the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies. This treaty states that outer space is not subject to national appropriation by claim of sovereignty (Article II) and that state parties to the treaty shall bear international responsibility for national activities in outer space (Article VI). Further, it declares in Article VIII that a state party to the treaty on whose registry an object launched into outer space is carried, shall retain jurisdiction and control over such object while in outer space or on a celestial body.

Thus, the purpose of the amendment is to provide that U.S. patent laws apply to inventions made in outer space on space vehicles under the jurisdiction or control of the United States. This is consistent with the purpose of the U.S. patent laws (to promote progress in the useful arts) by recognizing and rewarding inventions that advance space technology, as well as the policy and purposes of the U.S. space program as set forth in section 101 of the Space Act. It is also consistent with the President's Commercial Space Policy by encouraging increased industry investment in high technology and space-based research and development. One effect is to treat the Space Transportation System and eventually, the Space Station, as U.S. facilities in the same manner as a terrestrial-based facility would be treated in relation to inventions and patents under title 35. It would also apply to privately owned space platforms or other privately owned space vehicles.

As to establishing United States jurisdiction or control over a space vehicle, the registry of such in accordance with the Convention on the Registration of Objects Launched into Outer Space should be taken to establish prima facie jurisdiction and control. However, other indicia of jurisdiction or control may be established by commands originating in the United States, or by the fact that a space vehicle is owned by, and launched for, a United States entity.

This amendment is limited to prospective application only.

With the increase in space processing of materials and drugs on the Space shuttle, we feel it is important to have this language in the Space Act.

I thank you for your attention and will be glad to answer any questions.

Mr. GORDON. What about foreign platforms associated with the space station? Would they be considered under the jurisdiction and control of the United States?

Mr. HOSENBALL. If they are subject to our jurisdiction, if they are a part of our registration that we do at the U.N., and also over at the State Department, they would be. However, we're in the process of negotiating agreements with ESA and the Canadians, as well as the Japanese, and that's one of the questions that has arisen as to what laws will apply to the international partners in the space station. The memorandum of understanding does provide that, in the definition period for phase B, before they enter into CD, there will be a discussion of the various legal problems that might arise as a result of the international participation. The question of patents and jurisdiction is once of those questions.

Now, I've been reluctant to do that, to start those discussions now, primarily because we want to see what the configuration will be of the space station will be, what their contribution will be, what the activities will be that they will carry on, what sort of crew size there will be and crew membership, and so we think the proper time is to proceed in an orderly way. Let's go through the definition stage and see what their configuration will be. We won't be flying the space station until 1993, 1994, as far as operations are concerned; and what we did on shuttle was to look at the differences between shuttle and expendable; looked at the laws that might have to be changed, and we've come up here and made those suggested changes in the law. For example, we did extend criminal jurisdiction to the shuttle when we thought it was necessary.

Mr. GORDON. Well, what's going to be the criterion for jurisdiction?

Mr. HOSENBALL. Basically, the criteria is U.S. ownership, whether U.S. Government ownership or private industry ownership. If it's a U.S. entity, that gives U.S. jurisdiction and control, and therefore the patent laws will apply and any other laws that have some extraterritorial effect would also apply.

Mr. GORDON. Thank you very much, sir.

Welcome, Mr. Nysmith.

STATEMENT OF C. ROBERT NYSMITH, ASSOCIATE ADMINISTRATOR FOR MANAGEMENT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY DR. HOWARD ROBBINS, DEPUTY DIRECTOR, OFFICE OF MANAGEMENT, AND CHARLIE TULIP, DIRECTOR, INSTITUTIONAL PROGRAM ANALYSIS DIVISION, OFFICE OF THE COMPTROLLER

Mr. NYSMITH. Thank you, Mr. Chairman. This is my first time of testifying before the subcommittee, and it's a real pleasure for me.

I'd like to introduce the two gentlemen at the table with me. On my left is my deputy in the Office of Management, Dr. Howard Robbins, and on the right is Mr. Charles Tulip, who is the Director of the Institutional Program Analysis Division in the Office of the Comptroller.

I have a written statement for the record; I would like to foreshorten that somewhat in my oral statement and cover both R&PM and some other topics that I think might be of interest to you.

Mr. NELSON. Thank you.

Mr. NYSMITH. Together with the other NASA appropriations, the Research and Program Management appropriation provides the funding that enables NASA to continue to explore the frontiers of knowledge in aeronautics and space. Prior to discussing the details of the R&PM budget I'd like to say a few words about the R&PM budget in general, and I'll speak to this in terms of my background, really, as coming from technical management, both at a center, and in the Office of Aeronautics and Space Technology up until just a few short months ago.

Our record over the years is a testament to how successful we have been; however, NASA cannot and does not achieve these results by itself. Success has come about as a result of a partnership of industry, Government, and academe that is, I believe, unique. And this is no accident. Throughout its history, NASA—and NACA before it—worked very hard to encourage and maintain this partnership, and I maintain that one reason the partnership works so well is that NASA brings a very strong technical capability to the partnership. Technology is constantly moving forward, and the NASA capability moves forward with it. As a result, new missions are identified, approved, and accomplished, and then even more advanced missions are identified, and so forth.

The cycle never ends, nor should it. The key to a successful continuation is to maintain the in-house capability at the NASA centers that permits and even encourages this constant striving for the next step into the future. Thus, while specific R&D programs may come and go, maintenance of the NASA institutional capability as a national resource is the key to enabling the new missions of the future. That is the purpose of the R&PM appropriation. It supports the core capability of the NASA centers that enables new missions and R&D programs.

The R&PM budget is not overhead. Rather, it is at the heart of our capability in aeronautics and space. About 70 percent of the R&PM funds are required to pay the approximately 21,800 NASA civil servants, about half of which are scientists and engineers. These civil servants make up a significant portion of the Nation's aerospace engineering and technology core manpower capability. In 1984 we were able to recruit only about 250 recently graduated, fresh-out scientists and engineers, compared to about 600 in 1983. Civil service ceiling constraints were the primary reason for the decline. We hope to be able to recruit about 300 to 400 more fresh-out scientists and engineers, both in fiscal year 1985 and 1986, to help keep the NASA technical work force vital and assure the long-term health of that work force.

Since technology evolves so rapidly and it is essential that our technical people stay current with the state-of-the-art in their disciplines, we devote considerable attention and effort to providing our people with training and career development opportunities. This is particulary critical with our "new hire" S&E's since we try to compensate for our Agencywide pay shortfall with opportunities for continuing their graduate education while working at the centers. This pay shortfall now averages about $3,500 in annual starting salary, and ranges up to $10,000 in selected fields and geographical areas.

Finally, the remaining 30 percent of the R&PM funds provide for personnel travel and other services to support our staff and operate our centers. These activities are extremely diverse, ranging from utilities for operation of our facilities—many of which offer highly specialized, complex, unique capabilities—to the support of contractor services onsite at the centers. In essence, the quality of services and the capability of the centers is a direct function of the R&PM funding available.

As one final general observation, the management and leadership of the activities at our centers are the responsibility of our center directors, all of whom have risen from the ranks of the technical R&D managers. They are strongly motivated to maximize activities directed toward accomplishing their technical missions while minimizing activities oriented to administrative functions.

Now, before addressing NASA's budget request for 1986, I want to discuss with you briefly some changes from the fiscal year 1985 budget that we presented to you last year.

Of the 1985 research and program management request of $1.331 billion, $1.317 billion has been appropriated. Supplemental appropriations of $23.3 million are being requested to cover partially the $31 million cost of civil service pay and benefits raises and cost increases in 1985. A rescission of $4 million is pending as NASA's reduction related to section 2901 of the Deficit Reduction Act of 1984. If the requested supplemental is appropriated and the rescission approved, the 1985 plan for R&PM will be $1.3363 billion.

The total reductions in 1985 will be accommodated through deferring and delaying expenditures. In personnel and related costs, savings will be achieved through rephasing promotions and training, limiting temporary employment, and the amount of overtime and holiday pay. In operation of installation, reductions will be achieved by delaying and deferring purchases of supplies, materials, equipment, and contractual effort. In addition, our plan to increase operational maintenance has been deferred. These reductions are designed to minimize adverse impacts.

Turning now to our 1986 estimate of $1.345 billion, this is an increase of $8.7 million over the current 1985 estimate. This provides for personnel and related costs of 21,800 full-time equivalent civil service work years; a minimum level of travel to support Agency missions and programs and, essentially, level of effort programs in the other areas.

In the 1986 research and program management budget there are two significant changes from 1985. First, the salary rate for civil service personnel is 5 percent lower in 1986 than 1985. This reduction in salary rates is part of the Governmentwide reduction directed by the President to begin in fiscal year 1986. The other major change has been a reduction of 200 civil service full-time equivalents and $21 million related to the President's drive to reduce administrative costs in the Government. Even though the manpower and other administrative changes will be difficult to achieve, NASA will endeavor to accomplish the reductions in a manner that will have limited impact on program accomplishment. The balance of the changes in R&PM reflect a constant level of operations at expected price levels.

Now let me briefly summarize the 1986 request for the research and program management appropriation by functional category. I will not discuss personnel and related costs since I've just covered this subject.

Regarding travel, which is $31 million, since the vast majority of NASA funds are spent out of house, travel for both programmatic and management purposes is essential to the effective and economical accomplishment of program objectives. NASA's programs are largely accomplished in universities and industry and are sufficiently complex that onsite oversight and coordination is integral to their successful accomplishment. In addition, because NASA's civil service work force is so heavily technical, as I mentioned earlier, travel to scientific and technical meetings, seminars, and symposia is extremely important for the interchange of information. In 1986 the $1 million increase in travel over 1985 is the increase associated with the expected costs of travel, which are partially offset by a reduction in management and operations travel related to the President's drive to reduce administrative costs in Government.

In travel, we have been struggling over the past several years to assure an adequate budget in this area. In the 1984 pay supplemental, authority was provided for the Administrator to increase the travel limitations for 1984 and 1985. In 1984, we did not use the additional $500,000 provided because the approval came too late in the year to be used prudently. In 1985, however, we plan to increase the limitation by the full $2 million provided. This increase will cover much of the increase in travel requirements related to the space station. We believe that the 1986 level of travel is adequate to accomplish our program commitments.

In operation of installation, which is $382.187 million, the 1986 plan provides for anticipated changes in the price levels of support service contractor wage rates and utility rates; the alteration in the funding plans from reimbursable launch vehicle activities; and changes in the price levels for supplies, materials, equipment, and minor changes after partial offset by a reduction in the management and Operations subcategory related to the President's drive to reduce administrative costs. The amounts for facilities services, technical services, and management and operations are provided in the budget, and I will not discuss them here.

In summary, the 1986 budget requirement of $1.345 billion is to provide for 21,800 full-time equivalent Civil Service work years and to support the activities at 8 NASA installations and headquarters, consistent with the research and development, spaceflight, control and data communications, and construction of facilities program plans.

This concludes my statement on the research and program management budget. I'd like to highlight several other institutional items which may be of interest to you.

First, in the area of productivity and quality enhancement, last year we discussed several productivity improvement actions. I can now highlight some specific accomplishments in this area.

While our agency-wide Productivity Improvement and Quality Enhancement Program efforts are still getting underway, we have seen some good progress. Our employee suggestion program in fiscal year 1984 had approximately 1,100 suggestions for $3.5 million of savings, compared to 400 suggestions and $560,000 of savings in fiscal year 1983. We also have approximately 120 NASA employee teams which are based on the quality circle concept. These are in place, working on management improvements, and we have also initiated a NASA excellence award for quality and productivity to be given to those contractors having business in excess of $500,000 and who have demonstrated a total commitment—and I emphasize total—to continuous quality improvements.

In the area of automated information management, during the past year we developed the strategic office automation plan that established policy and goals which focused on coordination and integration by NASA of automated information technologies which encompass administrative data processing, or ADP, office automation and telecommunications into one cohesive technology.

We also have a number of Agency-wide system development activities in various states of study, development, or implementation. As one example, we have developed and are implementing a new on-line Agency-wide system for the accountability, management, and visibility of NASA's 300,000 items of controlled equipment, valued at over $5 billion. Named the NASA equipment management system, or NEMS, the system simplifies, standardizes, and reduces the cost of managing NASA's equipment through standard forms, standard hardware, and standard software. One of NEMS' greatest productivity improvements is the use of portable laser barcode scanners of the type used in grocery stores for inventorying equipment.

We are also studying automation of our payroll/personnel system, with the results to be available about June 1985, and our procurement system, with the procurement tracking module to be completed late this summer. We have many other study efforts underway.

We have one item which is an example of our efforts to reduce overhead costs, which is related to establishing a flat rate per diem for our employees. Last year, we were given the authority to conduct a 1-year test of the locality based flat rate per diem method of reimbursing travel expenses, starting in October 1984. This reimbursement method was applicable to NASA employees who travel within the United States on official business. We are only in the early phase and will not have complete data until next fall. However, my initial assessment of the value of this mode of travel reimbursement, based on comments by senior center officials, indicates that the time required to prepare, submit, and reimburse travel expenses has been reduced; travel funds are better utilized due to the expeditious liquidation of estimated travel costs; and better cash management has been achieved because travel advances are outstanding for a shorter period of time.

To quantify better the actual savings derived from the test, NASA financial management officers have been instructed to measure various key elements. This information will be gathered in the later stages of the test. Due to the initial indication of success, NASA has requested, in the 1986 budget request, that the test be extended until such time that permanent legislation is passed by Congress.

One other item is that last year, NASA was requested to assist the National Science Foundation in obtaining supercomputer capability that could be transferred to America's university campuses. We identified a supercomputer at the Lewis Research Center which was near saturation by researchers' requirements, and which offered an economic advantage to the Government to replace it at this time. An amendment to the 1984 supplemental appropriations bill provided NASA with the funds necessary to lease a compatible upgraded supercomputer as a replacement. The Lewis supercomputer is scheduled to be transferred to NSF late this year, as soon as efforts now underway at NASA to replace the Lewis system are completed. NASA has discussed with NSF the possibility of establishing a continuing program for transferring supercomputers to the universities through the NSF.

In the area of equal opportunity, we continue to make progress. We're dedicated to achieving our technical missions and goals with a fully integrated work force. Fiscal 1984 was another historic milestone with two additional American female astronauts and an additional black astronaut traveling in space on NASA space shuttle flights 41B, 41D, and 41G, respectively. NASA's demonstrated commitment to affirmative action for women and minorities who are underrepresented is reflected in the fiscal year 1984 Affirmative Action Program results, just several of which I'll highlight now.

In the area of hiring, 328 scientists and engineers hired; 132, or a little more than 40 percent, were minorities and nonminority women.

Of 135 professional administrative hires, 62, or over 45 percent, were minorities or nonminority women.

In the area of promotions, of 1,859 scientist and engineer actions, 531, or almost 30 percent, were minorities or nonminority women.

And of 709 professional administrative promotions, 464, or over 65 percent, were minorities and nonminority women.

In closing, I want to emphasize once more the importance of R&PM to the overall conduct of NASA's research, technology, development, and operations activities. Because all of our civil service people and their travel are funded from R&PM, the in-house research and the monitoring of out-of-house contractual work—which continue to be key elements in the Agency's success—will not be possible without it.

The activities supported by the R&PM appropriation are critical to maintaining the core capability of the NASA centers, which has been instrumental in the success of the aeronautics and space R&D Programs. R&PM is at the heart of assuring the quality of our people and our facilities, and represents an investment in the future.

I would be pleased to answer any questions that you might have.

[The prepared statement of Mr. Nysmith follows:]

STATEMENT
OF
C. ROBERT NYSMITH
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS, AND
SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS
COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

Messrs. Chairmen and Members of the Subcommittees:

Together with the Research and Development (R&D), Construction of Facilities (CofF) and the Space Flight, Control and Data Communications (SFCDC) appropriations, the Research and Program Management (R&PM) appropriation provides the funding that enables NASA to continue to explore the frontiers of knowledge in aeronautics and space. Prior to discussing the details of the R&PM budget, I would like to say a few words about the R&PM budget in general.

Our record over the years is a testament to how successful we have been. However, NASA cannot, and does not, achieve these results by itself. Success has come about as the result of a partnership by government, industry and academe that is, I believe, unique. And this is no accident. Throughout its history, NASA — and NACA before it — worked very hard to encourage and maintain this partnership. I maintain that one reason the partnership works so well is that NASA brings a very strong technical capability to the partnership. Technology is constantly moving forward and the NASA capability moves forward with it. As a result, new missions are identified, approved, and accomplished and then even more advanced missions are identified, and so forth.

The cycle never ends nor should it. The key to its successful continuation is to maintain the in-house capability at the NASA Centers that permits -- and even encourages — this constant striving for the next step into the future. Thus while specific R&D programs may come and go, maintenance of the NASA institutional capability as a National resource is the key to enabling the new missions of the future. That is the purpose of the R&PM appropriation. It supports the core capability of the NASA Centers that enables new missions and R&D programs.

The R&PM budget is not overhead — rather, it is at the heart of our capability in aeronautics and space. About 70 percent of the R&PM funds are required to pay the approximately 21,800 NASA civil servants — about half of which are scientists and engineers. These civil servants make up a significant portion of the Nation's aerospace engineering and technology core manpower capability. In 1984 we were able to recruit only about 250 recently graduated (fresh-out) scientists and engineers compared to about 600 in 1983. Civil Service ceiling constraints were the primary reason for the decline. We hope to be able to recruit about 300 to 400 both in 1985 and 1986 to help keep the NASA technical workforce vital and assure the long term health of that workforce.

Since technology evolves so rapidly and it is essential that our technical people stay current with the state-of-the-art in their disciplines, we devote considerable attention and effort to providing our people with training and career development opportunities. This is particularly critical with our "new hire" S&E's since we try to compensate for our Agencywide pay short-fall with opportunities for continuing their graduate education while working at the Centers. This pay short-fall now averages about $3,500 in annual starting salary and ranges up to $10,000 in selected fields and geographical areas.

Finally, the remaining 30 percent of the R&PM funds provide for personnel travel and other services to support our staff and operate our Centers. These activities are extremely diverse, ranging from utilities for operation of our facilities — many of which offer highly specialized, complex, unique capabilities — to the support of contractor services on-site at the Centers. In essence, the quality of services and the capability of the Centers is a direct function of the R&PM funding available.

As one final general observation, the management and leadership of the activities at our Centers are the responsibility of our Center Directors, all of whom have risen from the ranks of technical R&D managers. They are strongly motivated to maximize activities directed toward accomplishing their technical missions while minimizing activities oriented to administrative functions.

FY 1985 Budget Changes

Before addressing NASA's Budget Request for 1986, I want to discuss with you changes from the 1985 Budget presented to you last year.

Of the 1985 Research and Program Management request of $1,331,000,000, $1,317,000,000 has been appropriated. Supplemental appropriations of $23,300,000 are being requested to cover partially the $31,000,000 cost of civil service pay and benefits raises and cost increases in 1985. A recision of $4.0 million is pending as NASA's reduction related to Section 2901 of the Deficit Reduction Act of 1984. If the requested supplemental is appropriated and the recission approved, the 1985 plan for R&PM will be $1,336,300,000.

The total reduction in 1985 will be accommodated through deferring and delaying expenditures. In Personnel and Related Costs, savings will be achieved through rephasing promotions and training, limiting temporary employment, and the amount of overtime and holiday pay. In Operation of Installation, reductions will be achieved by delaying and deferring purchases of supplies, materials, equipment and contractual effort. In addition, our plan to increase operational maintenance has been deferred. These reductions are designed to minimize adverse impacts.

FY 1986 ESTIMATE

The 1986 budget estimate of $1,345,000,000, an increase of $8.7 million over the current 1985 estimate provides for: the personnel and related costs of 21,800 full-time equivalent (FTE) civil service workyears; a minimum level of travel to support Agency missions and programs; support service contractor effort at the anticipated wage rates; utility usage consistent with programmatic requirements at projected rates; and supplies, materials, equipment and other minor contracts and services at anticipated price levels. In the 1986 Research and Program Management Budget, there are two significant changes from 1985; first, the salary rate for civil service personnel is five percent lower in 1986 than 1985. This reduction in salary rates is part of the Governmentwide reduction directed by the President to begin in Fiscal 1986. The other major change has been a reduction of 200 civil service FTE's and $21.0 million related to the President's drive to reduce administrative costs in the Government. Even though the manpower and other administrative changes will be difficult to achieve, NASA will endeavor to accomplish the reductions in a manner that will have limited impact on program accomplishment. The balance of the changes in R&PM reflect a constant level of operations at expected price levels.

Now let me briefly summarize the 1986 request for the Research and Program Management appropriation by functional category.

1. Personnel and Related Costs ($931,813,000): The 1986 estimate for Personnel and Related Costs is $24.5 million lower than 1985 and is based on 21,800 FTE workyears, a reduction of 200 from 1985. This reduction, all in indirect civil service, is related to the President's Management Improvement Initiative to reduce administrative costs in the Government. In addition to the reduction of 200 FTE a further reduction of $42 million is the result of the effect of the proposed five percent reduction in civil service salaries. Both of these reductions are partially offset by the following: the full-year costs of the 1985 pay and benefits increase (which is in effect for only three-fourth of a year in 1985); the alteration in the mix between reimbursed and direct costs of civil service; the normal costs associated with within-grades, career development, merit pay, etc; and the reversion to the previous method of calculating salaries paid.

2. Travel ($31,000,000): Because the vast majority of NASA funds are spent out of house, travel for both programmatic and management purposes is essential to the effective and economical accomplishment of program objectives. NASA's programs are largely accomplished in universities and industry and are sufficiently complex that on-site oversight and coordination is integral to their successful accomplishment. In addition, because NASA's civil service workforce is so heavily technical (over 50 percent of NASA's permanent personnel are degreed scientists and engineers) travel to scientific and technical meetings, seminars and symposia is extremely important for the interchange of information. In 1986, the $1,000,000 increase in travel over 1985 is the increase associated with the expected costs of travel which are partially offset by a reduction in Management and Operations travel related

to the President's drive to reduce administrative costs in Government.

In Travel, we have been struggling over the past several years to assure an adequate budget in this area. In the 1984 pay supplemental, authority was provided for the Administrator to increase the travel limitations for 1984 and 1985. In 1984, we did not use the additional $500 thousand provided because the approval came too late in the year to be used prudently. In 1985, however, we plan to increase the limitation by the full $2.0 million provided. This increase will cover much of the increase in travel requirements related to the Space Station. We believe that the 1986 level of travel is adequate to accomplish our program commitments.

3. Operation of Installation ($382,187,000): The 1986 plan provides for: anticipated changes in the price levels of support service contractor wage rates and utility rates; the alteration in the funding plans from reimbursable launch vehicle activities; and changes in the price levels for supplies, materials, equipment and minor changes after partial offset by a reduction in the Management and Operations subcategory related to the President's drive to reduce administrative costs. The amounts by subcategory are as follows:

A. Facilities Services ($212,272,000): The 1986 estimate, an increase of $29,269,000 over the 1985 current estimate, covers the fullyear effect of minor changes in facilities services begun in 1985, and anticipated rate and price increases for utilities, support contractor wage rates, supplies, materials, equipment and minor contractual effort.

B. Technical Services ($66,071,000): The $10,558,000 increase in 1986 covers anticipated support service contractor wage rates and the costs of supplies, materials, equipment and minor contractual effort as well as the continuation of improvements to automated information systems.

C. Management and Operations ($103,844,000): The $7,637,000 decrease in this subcategory is the result of the reduction in administrative costs, partially offset by the increased costs of supplies, materials, equipment and minor contractual effort, and the anticipated change in support service contractor wage rates.

In summary, the 1986 budget requirement of $1,345,000,000 is to provide for 21,800 full-time equivalent civil service workyears and to support the activities at eight NASA installations and Headquarters, consistent with the research and development, spaceflight, control and data communications, and construction of facilities program plans.

This concludes my statement on the Research and Program Management Budget. I will now highlight several other institutional items which may be of interest to you.

NASA PRODUCTIVITY AND QUALITY ENHANCEMENT

Last year we discussed several productivity improvement actions. I can highlight some accomplishments in that area.

While our Agencywide Productivity Improvement and Quality Enhancement program efforts are still getting underway, we have seen some good progress. Our employee suggestion program in FY 1984 had approximately 1,100 suggestions for $3.5 million of savings, compared to 400 suggestions and $560 thousand of savings in FY 1983. We have approximately 120 NASA Employee Teams (based on the Quality Circle concept) in place working on management improvements, and we initiated a NASA Excellence Award for quality and productivity to be given to those contractors having business in excess of $500,000 and who have demonstrated a total commitment to continuous quality improvements.

AUTOMATED INFORMATION MANAGEMENT (AIM)

During the past year a strategic office automation planning team established policy and goals which focused on coordination and integration by NASA of Automated Information technologies encompassing Administrative Data Processing, Office Automation and Telecommunications into one cohesive technology. The Strategic Plan further established an AIM Council made up of Headquarters and Center representatives, to ensure review and coordination of AIM requirements across the Agency.

A number of Agencywide system development activities are in various states of study, development or implementation. As several examples, we have developed and are implementing a new on-line Agencywide system for the accountability, management, and visibility of NASA's 300,000 items of controlled equipment valued at over $5 billion. Named the NASA Equipment Management System or NEMS, the system simplifies, standardizes, and reduces the cost of managing NASA's equipment through standard forms, standard hardware, and standard software. One of NEMS' greatest productivity improvements is the use of portable laser barcode scanners for inventorying equipment.

To improve the management of our supplies, we developed and are implementing a new Economic Order Quantity formula which reduces our supply levels with no appreciable impact on the support of our operations.

Through a contractual arrangement with the American Institute for Aeronautics and Astronautics (AIAA), we are marketing in the United States our Bibliographic tapes of unrestricted documents. Lockheed Dialog and Mead Data Systems will have this bibliographic data accessible through their online services beginning this year. Resulting revenues will offset contract costs between NASA and AIAA and increase the number of accessions of foreign scientific and technical documents to our data base.

We are also studying automation of our Payroll/Personnel system with the results to be available about June 1985, and our Procurement System with the procurement tracking module to be completed late this summer.

Many study efforts are presently underway today which could ultimately effect the manner and style in which NASA conducts many of its administrative operations. These efforts plan to offer large groups of users the opportunity to automate existing manual operations and reduce or avoid costs.

FLAT RATE PER DIEM

An example of our efforts to reduce overhead costs is in the reimbursement of travel costs of our employees. Last year, we were given the authority to conduct a one year test of the Locality Based Flat Rate Per Diem method of reimbursing travel expenses starting on October 1984. This reimbursement method was applicable to NASA employees who travel within the United States on official business. We are only in the early phase and will not have complete data until next fall. However, my initial assessment of the value of this mode of travel reimbursement based on comments by senior center officials to me indicates that:

- The time required to prepare, submit, and reimburse travel expenses has been reduced.

- Travel funds are better utilized due to the expeditious liquidation of estimated travel costs.

- Better cash management has been achieved because travel advances are outstanding for a shorter period of time.

To quantify better the actual savings derived from the test, NASA Financial Management Officers have been instructed to measure various key elements. This information will be gathered in the later stages of the test. Due to the initial indication of success, NASA has requested, in the 1986 Budget Request, that the test be extended until such time that permanent legislation is passed by Congress.

NATIONAL SCIENCE FOUNDATION SUPER COMPUTER SUPPORT

Last year, NASA was requested to assist the National Science Foundation (NSF) in obtaining super computer capability that could be transferred to America's university campuses. We identified a super computer at the Lewis Research Center which was near saturation by researchers' requirements and which offered an economic advantage to the Government to replace at this time. An amendment to the 1984 Supplemental Appropriations Bill provided NASA with funds necessary to lease a compatible upgraded super computer as a replacement. The Lewis super computer is scheduled to be transferred to NSF late this year, as soon as efforts now underway at NASA to replace the Lewis system are completed. NASA has discussed with NSF the possibility of establishing a continuing program for transferring super computers to the universities through NSF.

EQUAL OPPORTUNITY

NASA continues to make progress in the area of equal opportunity. The Agency is dedicated to achieving its technical missions and goals with a fully integrated workforce. FY 1984 marked another historic milestone with two additional American female astronauts and an additional Black astronaut traveling in space on NASA Space Shuttle Flights 41-B, 41D and 41G, respectively. NASA's demonstrated commitment to affirmative action for women and minorities who are underrepresented is reflected in the FY 1984 Affirmative Action Program results:

Hires

- 328 scientists and engineers; 132 (40.2%) minorities and non-minority women.
- 135 professional administrative; 62 (45.9%) minorities and non-minority women.
- 378 technicians, wage grade, and Cooperative Education Program employees; 161 (42.6%) minorities and non-minority women.
- 469 clerical support employees; 128 (27.3%) minorities.

Promotions

- 1,859 scientists and engineers; 531 (28.6%) minorities and non-minority women.
- 709 professional administrative; 464 (65.4%) minorities and non-minority women.
- 1,324 technicians, wage grade and Cooperative Education Program Employees; 405 (30.6%) minorities and non-minority women.
- 823 clerical support employees; 240 (29.2%) minorities.

In addition, 37 handicapped persons with targeted disabilities were hired including a disabled veteran with a 30% or more disability. This included 20 in permanent or positions leading to permanent assignments, and 25 summer hires utilizing a variety of summer employment programs. Thirty-one (31) severely handicapped individuals were promoted.

In closing, I want to emphasize once more the importance of R&PM to the overall conduct of NASA's research, technology, development, and operations activities. Because all of our civil service people and their travel is funded from R&PM, the in-house reseach and the monitoring of out-of-house contractual work (which continue to be key elements in the Agency's success) will not be possible without it.

The activities supported by the R&PM Appropriation are critical to maintaining the core capability of the NASA Centers which has been instrumental in the success of the aeronautics and space R&D programs. R&PM assures the quality of our people and our facilities and represents an investment in the future.

I would be pleased to answer any questions you may have.

Mr. **Nelson**. Thank you, Mr. Nysmith.

You mentioned the $21 million cut in the President's drive to reduce administrative costs. How will you cut the personnel?

Mr. **Nysmith**. Well, part of that has to do with the 200 reduction from 22,000 to 21,800. Now, that's not the full $21 million cut; I believe the number associated with that 200 people is $8 million. If I could ask Mr. Tulip to talk to the other part of that $21 million.

Mr. **Tulip**. Well, the 200 people will come out of all of our indirect complement, which amounts to about 4,500 across the Agency. The balance of the $21 million—$½ million will come out of administrative travel, and the other $12.5 million will come out of the management operations part of the operations of installations, and will come out of things like communications, transportation, common services across the centers, and so forth. The specifics we're in the process of working out right now. As you can imagine, that's not an easy thing to do.

Mr. **Nelson**. Mr. Walker.

Mr. **Walker**. Thank you, Mr. Chairman.

Mr. Chairman, I ask unanimous consent that an opening statement that I had prepared here—very complimentary of the chairman, I might say—be put into the record.

Mr. **Nelson**. Well, please read it. [Laughter.]

Without objection.

Mr. **Walker**. Thank you, Mr. Chairman.

[The prepared opening statement of Mr. Walker follows:]

OPENING STATEMENT HON. ROBERT S. WALKER, SSA SUBCOMMITTEE HEARING—MARCH 6, 1985

Good morning, Mr. Chairman. I would like to join you in welcoming our witnesses here today.

We are approaching the end of a busy and very productive authorization cycle. I would like to take this opportunity to express my appreciation to the chairman for his unfailing courtesy and cooperation in the process.

I would also like to say that we all have heavy demands on our time, and I particularly appreciate the interest shown by our new Republican members who have been extraordinarily conscientious in their attendance this year.

This subcommittee forces a number of decisions this year which will directly affect the American future in space. Our hearings have been comprehensive. The level of interest has been high. And I would like to thank the chairman for making sure that each member has had adequate opportunity to fully explore the issues before us.

Mr. **Walker**. As management specialists, what's going to be the impact of the 5-percent, across-the-board cut in pay, do you think?

Mr. **Nysmith**. Well, I think that the 5 percent pay cut will have an impact in several different levels within the Agency. The NASA people are amazingly committed to the program. What is concerning most of us is that we have a very difficult time today competing for fresh-outs and new hires. We are still getting very high quality people. We're getting them because of the kind of programs we have and the kind of, let's say, facilities that we have that they can come to work at, which are unique. Right now we're having a difficult time competing, though, and I mentioned the numbers of a $3,500 starting salary problem; I mentioned in some cases, as an example computer science, things like $10,000 differences. I think the 5-percent pay cut will have a negative impact on our being able to attract the young people. It's a little bit of another negative.

It's difficult these days to sell Federal employment to these people, and this is one more negative. Now, at the higher levels in NASA, people who are already here, I don't think it will have a major impact. I think the people that are on board are for the most part committed to stay; the 5 percent difference, I don't think it's going to run anyone out—well, maybe a few people, but in general, not. I see it more of a problem right down at the hiring level, and in keeping them.

Mr. **Walker**. You seem to be saying that you don't think it will lead to, at least within NASA, a substantial morale problem within the Agency?

Mr. **Nysmith**. Well, I think taken by itself—if it were by itself—it would not create a morale problem. But it, taken with everything else, is another straw, and that's the problem.

Mr. **Walker**. And would you guess that some of the problems would be negated by a pay freeze rather than an actual pay cut?

Mr. **Nysmith**. Yes; I think it would be negated by that.

Mr. **Walker**. Thank you, Mr. Chairman.

Mr. **Nysmith**. It's still not a very positive message for Federal employees.

Mr. **Walker**. I understand.

Mr. **Nelson**. Well, we appreciate it, Mr. Nysmith. Thank you very much.

Mr. **Nysmith**. Thank you.

Mr. **Nelson**. General McGarvey?

STATEMENT OF GEN. BILLIE J. McGARVEY, DIRECTOR OF FACILITIES ENGINEERING, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY RICHARD IRWIN, DEPUTY DIRECTOR FOR FACILITIES ENGINEERING

General **McGarvey**. Mr. Chairman, I'd like to introduce Dick Irwin, Deputy Director for Facilities Engineering, sitting on my right. I have a very short prepared statement which I would like to read—it's not more than about 5 minutes—and highlights the majority of the activities in the facilities engineering arena.

Mr. Chairman and members of the subcommittees, I appreciate this opportunity to present the NASA construction of facilities budget request for 1986. Our budget request is $149.3 million. This is $700,000 less than the 1985 appropriation of $150 million. This is a modest but balanced budget request for construction activities that are vital to providing reliable and responsive facility support in carrying out the mainline research, development, and testing responsibilities of the Agency. The fiscal year 1986 request has been structured to meet our continuing objective of preserving and enhancing the capabilities and effectiveness of our unique aerospace research, development, and test facilities and our supporting institutional facilities and systems. There is $82.3 million requested for discrete facility projects, $55 million for minor projects, and $12 million for planning and design.

Prior to addressing the 1986 requirements, there are a number of significant construction activities completed or implemented in the past year that I am sure are of interest to you. Let me quickly update you on some of those projects.

Modification of the central air system at the Lewis Research Center was completed and placed in operation last year. This was a $13.4 million modernization effort that provides centralized monitoring, control, and data acquisition of center-wide distribution systems of conditioned air to the engine research labs and the propulsion systems test positions. The project represents the leading technology in the country for monitoring and control systems.

Construction and activation of the Man-Vehicle Systems Research Facility at the Ames Research Center was also completed. This facility provides a vital national research capability for aeronautical human factors research. This unique R&D facility provides ground test simulation of multiple aircraft, air traffic control, air crew interactions, and advanced technology cockpit displays, all within a full-mission context. This was an $8.2 million project.

A $12.4 million project for the construction of solid rocket booster processing and segment storage facilities was completed and placed in operation at the Kennedy Space Center. This provides a dedicated facility for SRB processing and storage for two flight sets required to support space shuttle operations and enhances the safety of other shuttle processing activities in the Launch Complex 39 area.

New 34-meter antennas for the Deep Space Network Stations at Goldstone, CA, and Tidbinbilla, Australia, were also constructed and activated during this period. These antennas will provide improved multiple mission support for the deep space planetary missions in the late 1980's and 1990's, the first of which is the upcoming Voyager-Uranus encounter in 1986. Construction costs were approximately $12.2 million.

We also initiated the design and construction of a critically-needed central engineering building at the Jet Propulsion Laboratory last year. With the approval of the Congress, this $17 million facility is being constructed through an agreement with the California Institute of Technology whereby the university is financing the design and construction, and NASA will amortize the investment over a 12-year period.

Our budget request includes seven major projects that are needed to enhance and exploit the full capabilities of the space shuttle. One of these key projects is the construction of an orbiter modification and refurbishment facility at the Kennedy Space Center at an estimated cost of $14 million. The purpose is to provide an offline facility for orbiter modifications, refurbishment, and overhaul operations to preclude interrupting the orbiter launch processing flow activities in the orbiter processing facility itself. The facility is needed to maintain the integrity of the Space Transportation System and to exploit its full capabilities.

Another major project in this category is one at the Marshall Space Flight Center titled "Modifications for Advanced Technology Engine Test Stand S-1C," which is the old Saturn 1-C stand at Marshall. The requested project modifies this existing engine test stand to provide the capability for testing and integrating enhancements for the space shuttle main engines. An integrated subsystem test bed is required to permit integration of new engine technology without impacting the production, development, and testing programs at Santa Susana and NSTL. The estimated cost for the necessary test stand is $6.5 million.

One final project that I would like to highlight that is required to improve our Space Transportation Systems operations is the modification to the Pad A Payload Change-Out Room at the Kennedy Space Center, at an estimated cost of $2.2 million. The modifications are needed to provide improvements in the operational payload processing at the launch pad. The modifications are located at the 130-foot level of the rotating service structure on the launch pad, and provide environmentally-controlled storage areas, personnel support areas, and access platforms for auxiliary power carts.

In the space science and applications area, the construction of the first increment of a spacecraft system development and integration facility at the Goddard Space Flight Center is included in our request for $8 million. This facility is needed to accommodate simultaneous, multiyear development and integration of two large spacecraft up to the size of the space shuttle full cargo bay capability. The facility would also provide the capability for major or long-term refurbishment of two large spacecraft. A second and final increment of construction to complete the facility is planned for fiscal year 1987.

Another key facility that is needed to enhance our research and technology development efforts in space science is a microdevices laboratory at the Jet Propulsion Laboratory in the amount of $8.9 million. This project is required to adequately support advanced microelectronics research and technology development efforts for very high radiation resistant and highly reliable microelectronic devices that are required for future spacecraft and to sustain NASA's lead in space mission technology and capability.

In the aeronautics side of the house, one of the most critically needed projects for enhancing our research and technology development in aeronautics is the numerical aerodynamics simulation facility at the Ames Research Center; $8.2 million is included in this budget request to permit the completion of the project, which was partially funded in fiscal year 1985. This final phase of construction is required to provide a complete and usable facility for housing the numerical aerodynamic simulation activities that will provide a national high-speed computational capability that is necessary in ensuring a continuing leadership in computational fluid dynamics and related disciplines.

A second key aeronautics facility project is the modification of the 16-foot transonic tunnel at the Langley Research Center at an estimated cost of $4.9 million. The construction modifications are needed to provide a significant increase in productivity and provide a new capability for airframe/propulsion integration research. The modifications include new model preparation and calibration areas, new model support systems with increased angle-of-attack, dual air-flow propulsion system, and new drive system speed control. The net increase in productivity of this high-use tunnel will be in the 25 to 30 percent range.

In the space tracking and data systems area, two projects for upgrading the large 64-meter antennas at the deep space network stations at Goldstone, CA and Tidbinbilla, Australia are included in the budget request for $8.5 and $8.9 million, respectively. The antenna dishes will be increased in diameter to the full reflector surface. These modifications are needed now to improve the communications capability for the deep space missions such as Galileo, Venus Radar Mapper, the Voyager II-Neptune encounter, and spacecraft traveling beyond the outer planets.

In closing, I would like to again request your continued full support of the level of funding that we are requesting for our minor programs. The repair, rehabilitation and modification, and minor construction projects that make up the minor programs continue to provide the backbone for NASA's facility support activities and institutional capability. These projects, with strong support by you, have enabled us to address many of our most pressing and widespread smaller facility problems. With facilities the age of ours, extensive repairs are needed every year to continue to protect the Government's investment in these unique and valuable aerospace R&D facilities that make up the NASA physical plant. Likewise, technology advances and breakthroughs have been achieved and will continue to be achieved in the future with the necessary facility support that is provided, in large part, by the rehabilitation and modification of existing facilities. This category of work has been instrumental in enabling NASA to retailor our laboratories and test facilities to undertake new tasks and exploit technology developments. These projects not only preserve and enhance the capabilities and usefulness of our facilities, but also help ensure their continued safe and economical use. In a like manner, the minor construction projects permit us to build limited but essential additions or new facilities that are critically needed.

Finally, I would like to thank you again for your solid support of the NASA COF budget request and the vital facility program that it supports. This completes my statement, and I will be happy to attempt to answer any of your questions.

[The prepared statement plus answers to questions asked of General McGarvey follow:]

HOLD FOR RELEASE
UNTIL
PRESENTED BY
WITNESS
MARCH 6, 1985

STATEMENT
OF

BILLIE J. MCGARVEY
DIRECTOR OF FACILITIES ENGINEERING

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS, AND
SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS
COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

Messrs. Chairmen and members of the Subcommittees:

I appreciate this opportunity to present the NASA Construction of Facilities budget request for FY 1986. Our budget request is for $149.3 million. This is $700 thousand less than the FY 1985 appropriation of $150 million. This is a modest but balanced budget request for construction activities that are vital to providing reliable and responsive facility support in carrying out the mainline research, development, and testing responsibilities of the Agency.

The FY 1986 request has been structured to meet our continuing objective of preserving and enhancing the capabilities and effectiveness of our unique aerospace research, development, and test facilities and our supporting institutional facilities and systems. $82.3 million is requested for discrete facility projects, $55 million for minor projects, and $12 million for planning and design.

Prior to addressing the FY 1986 requirements, there are a number of significant construction activities completed or implemented in the past year that I am sure are of interest to you. Let me quickly update you on some of the major projects:

Modification of the Central Air System at the Lewis Research Center was completed and placed in operation last year. This was a $13.4 million modernization effort that provides centralized monitoring, control, and data acquisition of center-wide distribution systems of conditioned air to the engine research labs and the propulsion systems test positions. The project represents the leading technology in the country for monitoring and control systems.

Construction and activation of the Man-Vehicle Systems Research

Facility at the Ames Research Center were also completed. This facility provides a vital national research capability for aeronautical human factors research. This unique R&D facility provides ground test simulation of multiple aircraft, air traffic control, air crew interactions, and advanced technology cockpit displays, all within a full-mission context. This was an $8.2 million project.

A $12.4 million project for the construction of Solid Rocket Booster Processing and Segment Storage Facilities was completed and placed in operation at the Kennedy Space Center. This provides a dedicated facility for SRB processing and storage for two flight sets required to support Space Shuttle operations and enhances the safety of other shuttle processing activities in the Launch Complex 39 area.

New 34-Meter Antennas for the Deep Space Network Stations at Goldstone, California and Tidbinbilla, Australia were also constructed and activated during this period. These antennas will provide improved multiple mission support for the deep space planetary missions in the late 1980's and 1990's, the first of which is the upcoming Voyager-Uranus encounter in 1986. Construction costs were approximately $12.2 million.

We also initiated the design and construction of a critically needed Central Engineering Building at the Jet Propulsion Laboratory last year. With the approval of the Congress, this $17 million facility is being constructed through an agreement with the California Institute of Technology whereby the university is financing the design and construction, and NASA will amortize their investment over a twelve-year period.

SPACE TRANSPORTATION SYSTEM FACILITIES

Our budget request includes seven major projects that are needed to enhance and exploit the full capabilities of the Space Shuttle. One of these key projects is the construction of an Orbiter Modification and Refurbishment Facility at the Kennedy Space Center at an estimated cost of $14 million. The purpose is to provide an off-line facility for orbiter modifications, refurbishment, and overhaul operations to preclude interrupting the orbiter launch processing flow activities in the orbiter processing facility. The facility is needed to maintain the integrity of the Space Transportation System and exploit its full capabilities.

Another major project in this category is one at the Marshall Space Flight Center titled Modifications for Advanced Technology Engine Test Stand S-1C. The requested project modifies an existing engine test stand S-1C to provide the capability for testing and integrating enhancements for the Space Shuttle Main Engines. An integrated subsystem test bed is required to permit integration of new engine technology without impacting the production, development, and testing programs at Santa Susana and NSTL. The estimated cost for the necessary test stand modifications is $6.5 million.

One final project that I would like to highlight that is required to improve our STS operations is the Modifications to the Pad A Payload Change-Out Room at the Kennedy Space Center at an estimated cost of $2.2 million. The modifications are needed to provide improvements in the operational payload processing at the launch pad. The modifications are located at the 130-foot level of the rotating service structure on the launch pad and provide environmentally controlled storage areas, personnel support areas, and access platforms for auxilliary power carts.

SPACE SCIENCE AND APPLICATIONS

The construction of the first increment of a Spacecraft System Development and Integration Facility at the Goddard Space Flight Center is included in our request at $8 million. This facility is needed to accommodate simultaneous, multi-year development and integration of two large spacecraft up to the size of the Space Shuttle full cargo bay capability. The facility would also provide the cability for major or long-term refurbishment of two large spacecraft. A second and final increment of constuction to complete the facility is planned for FY 1987.

Another key facility that is needed to enhance our research and technology development efforts in space science is a Microdevices Laboratory at the Jet Propulsion Laboratory in the amount of $8.9 million. This project is required to adequately support advanced microelectronics research and technology development efforts for very high radiation resistant and highly reliable microelectronic devices that are required for future spacecraft and to sustain NASA's lead in space-mission technology and capability.

AERONAUTICS FACILITIES

One of the most critically needed projects for enhancing our research and technology development in aeronautics is the Numerical Aerodynamics Simulation Facility at the Ames Research Center. $8.2 million is included in this budget request to permit the completion of the project which was partially funded in FY 1985. This final phase of construction is required to provide a complete and usable facility for housing the Numerical Aerodynamic Simulation activities that will provide a National high-speed computational capability that is necessary in insuring a continuing leadership in computational fluid dynamics and related disciplines.

A second key aeronautics facility project is the Modification of the 16-Foot Transonic Tunnel at the Langley Research Center at an estimated cost of $4.9 million. The construction modifications are needed to provide a significant increase in productivity and provide new capability for airframe/propulsion integration research. The modifications include new model preparation and calibration areas, new model support systems with increased angle-of-attack, dual air-flow propulsion system, and new drive system speed control. The net increase in productivity of this high-use tunnel will be in the 25/30 per cent range.

SPACE TRACKING AND DATA SYSTEMS

Two projects for upgrading the large 64-meter Antennas at the Deep

Space Network stations at Goldstone, California and Tidbinbilla, Australia are included in the budget request for $8.5 million and $8.9 million. The antenna dishes will be increased in diameter to 70-meters, and high efficiency x-band panels will be installed over the full reflector surface. These modifications are needed now to improve the communication capability for the deep space missions such as Gallileo, Venus Radar Mapper, the Voyager 2-Neptune encounter, and spacecraft traveling beyond the outer planets.

MINOR FACILITY PROJECTS

In closing, I would like to again request your continued full support of the level of funding that we are requesting for our minor programs. The Repair, Rehabilitation and Modification, and Minor Construction projects that make up the minor programs continue to provide the backbone for NASA's facility support activities and institutional capability. These projects, with strong support by you, have enabled us to address many of our most pressing and wide-spread smaller facility problems. With facilities the age of ours, extensive repairs are needed every year to continue to protect the government's investment in these unique and valuable aerospace R&D facilities that make up the NASA physical plant. Likewise, technology advances and breakthroughs have been achieved and will continue to be achieved in the future with the necessary facility support that is provided in large part by the rehabilitation and modification of existing facilities. This category of work has been instrumental in enabling NASA to retailor our laboratories and test facilities to undertake new tasks and exploit technology developments. These projects not only help preserve and enhance the capabilities and usefulness of our facilities but also help insure their continued safe and economical use. In a like manner, the minor construction projects permit us to build limited but essential additions or new facilities that are critically needed.

SUMMARY

Finally, I would like to thank you again for your solid support of the NASA CoF budget request and the vital facility program that it supports. This completes my prepared statement, and I will be pleased to address any questions you may have.

Questions submitted by Chairman Nelson, during the March 6, 1985, hearing.

QUESTION NX-1:

General McGarvey, would you please give us your overall opinion of the general state of NASA's real property? In other words, do you feel that there is work that is essential, but for budgetary reasons it is not being done?

ANSWER NX-1:

The highest priority programmatic and institutional construction projects survive the vigorous internal and Administration reviews. However, on the other hand, no NASA programs or mainline activities have been delayed or deferred for the lack of adequate facility support. We have many valid requirements that must be deferred due to budget limitations, but on balance our budget does accommodate the priority needs.

QUESTION NX-2:

Is NASA's "rehabilitation and modification" program maintaining pace with NASA's changing programmatic needs?

ANSWER NX-2:

The $27M request in this year's program was distilled from over $48M of candidate projects and is fairly representative of the past 3 to 4 years. About 60% of the projects are allocated to programmatic requirements and the remainder to institutional needs. Unfortunately, this category of projects along with Repair and Minor Construction are often singled out when reductions are made by Congress. This category of work is most essential to improving the capabilities and usefulness of our facilities and to insuring that the facilities are available on a continuous, reliable basis.

QUESTION NX-3:

Does the "minor construction" program adequately provide for NASA's additional programmatic needs?

ANSWER NX-3:

The highest priority needs are satisfied, but many other valid requirements are deferred due to budget constraints. This year's request of $6M was scrubbed down from over $12M of requests from our field centers. Similar to Rehab & Modification projects, a little over 60% is allocated to priority programmatic needs. The additional capabilities provided and the reconfiguration and utilization of key facilities are most helpful in meeting changes in missions and programs.

QUESTION NX-4:

General McGarvey, will you explain to the Committee the work that is accomplished under "facility planning and design," and tell us how this benefits NASA programs?

ANSWER NX-4:

The resources requested for "facility planning and design" will be applied to studies, preliminary engineering reports and final design of facilities projects, and related activities supporting the preservation and enhancement of the NASA physical plant. Specifically, these funds will be applied to design of projects for which construction funds will be included in the Fiscal Year 1987 and 1988 programs and for studies and preliminary engineering for Fiscal Year 1988 and 1989 candidate projects.

In the planning phases of projects, investigations, studies, and preliminary engineering provide the basic data, preliminary cost estimates and schedules for reliable budget proposals , and also provide a point of departure for final design. Later, final design (analyses, calculations, plans, drawings, and construction specifications), refined cost estimates, construction schedules, and bid solicitation packages are completed with these resources. It routinely exceeds two years from the initial inquiry into potential means of meeting an operational need until final design for a project is completed. Therefore, funds for carrying out these activities are required two or more years before the start of construction. This permits working towards completion of design, prior to, or concurrently with the receipt of construction funds to permit the prompt award of construction contracts.

These resources also provide for broad-based facility studies and engineering support to keep abreast of changing trends in construction, costs, materials, and building codes. These resources are also used in preparing the necessary studies, investigations, and assessments for complying with the myriad of environmental requirements as well as supporting energy conservation efforts.

The foregoing touches upon the many activities that are accomplished with "facility planning and design" resources. The benefits are many and far exceed the modest amounts expended. Of prime importance are the orderly development of facility projects, increased accuracy in cost estimates, better construction schedules, fewer construction change orders, more facility for the construction dollar, and reduced life cycle costs.

QUESTION NX-5:

Concerning the project titled, "Construction of Orbiter Modification and Refurbishment Facility," if this facility is designed and built as described in the budget, will it be possible at a later date to add "service and deservice" systems and equipment if it should be found later that these additional facilities are necessary to meet flight schedules?

ANSWER NX-5:

Yes. The planned facility is configured and provided with the basic utilities for outfitting as a 3rd Orbiter Processing Bay in the future if the increased flight rates should require it. (Roughly $12 to $14 million of additional Construction of Facilities resources would be required together with a significant amount of R&D funded equipment.)

QUESTION NX-6:

Will the forty-two thousand square foot thermal protection system facility for Kennedy provide sufficient space and related equipment to accommodate work on two orbiters at the same time?

ANSWER NX-6:

Yes. The facility will provide the capability for processing and preparing the thermal tiles for two orbiters at the same time. Tile repairs, fabrication, bonding, cleaning and coating activities will be performed in this centralized facility. The installation of the tiles on the orbiters is performed in the two high bays of the nearby Orbiter Processing Facility.

QUESTION NX-7:

Concerning the construction of additions at the Research Project Laboratory at the Goddard Space Flight Center; the budget refers to the use of hazardous gaseous and highly toxic substances, has NASA prepared an environmental impact statement to cover the functions and facilities involved? How will these gaseous and toxic substances be disposed of?

ANSWER NX-7:

The conduct of research on the molecular spectroscopy of various elements at the Research Projects Laboratory involves the use and storage of very small quantities of a variety of hazardous gases. The Code of Maryland Regulations relating to air quality, specifically excludes bench scale laboratory equipment used exclusively for chemical or physical analysis or experimentation from the need for permitting. This exemption makes the operation of this laboratory acceptable under the existing GSFC Environmental Resources Document.

The new facility will be equipped with laboratory exhaust hoods at each experimental station, and the building will be equipped with an auxiliary exhaust system. These systems will be capable of operating at 100% exhaust in the event of an emergency evacuation. During normal as well as emergency operations these systems will mix the small volumes of gases with large volumes of fresh air and discharge the extremely diluted gases directly to the environment through high stacks (approximately 37 ft. above grade). This is the standard, accepted procedure used by universities, industry, and government research laboratories.

QUESTION NX-8:

Why has the total estimated cost of the Numerical Aerodynamic Simulation Facility at the Ames Research Center increased $3.2 million in FY 1986? What change in the ENR construction cost index (a standard industry price/cost index for construction which is published by McGraw-Hill) for the type of work in question occurred during the one year deferral? What is the present status of this project, and what is the scheduled completion date?

ANSWER NX-8:

The $3.2M includes $600,000 for escalation, delay, and rephasing construction packages (3.6% of $16.5M) and $2,6000,000 for secure data processing requirements. A secure data processing area is needed so that NASA can process sensitive security research data from DOD sources for use in both NASA and DOD research activities.

The ENR construction per cent change is 2.8 - 3.7 during the one-year deferral period.

The project is presently under contract with a scheduled completion date of December 1986, exclusive of the security modifications. The construction of the secure area is planned to start in early 1986 with a construction period estimated at approximately one year.

Mr. **Walker**. Just one. I didn't notice any mention of money in here, and it may just be that it's being completed this year, for the second launch facility at Kennedy. Is that being completed? And so, therefore, there is no need for money in the 1986 budget?

General **McGarvey**. That's correct. The launch pad B, the second launch pad, will be completed by January of 1986, and all of the facility work is funded and virtually 95 or 96 percent of it is completed at this point in time.

Mr. **Walker**. Thank you, Mr. Chairman.

Mr. **Nelson**. The Research Project Laboratory at Goddard—the budget refers to the use of hazardous gasses and highly toxic substances. Do you have an environmental impact statement to cover these functions and the facilities involved? And then tell me how you are going to dispose of those gasses.

General **McGarvey**. Yes, Mr. Chairman, the Toxic Gas Laboratory is an existing activity at Goddard. This is not a new function or a new activity. It has been conducted in building No. 2, the Project Research Laboratory, and it is covered and has been covered in the past under our blanket environmental impact statement for Goddard Space Flight Center. And as you probably know, we have environmental impact statements for the Center operations for all of our centers. We have not singled it out for a separate environmental impact statement and do not believe that one is necessary, since this is a continuing activity of things that we have been carrying on for a number of years at Goddard. What we are concerned about is removing that hazardous operation from the building and getting it into a separate building in order that we don't have a problem with the ventilation system or air conditioning system in the existing building, and those gasses being accidentally injected into the existing systems. The new facility has a very sophisticated ventilation and purging system in the design of it, and each of—there's about seven small lab areas in that particular facility—each of those have their own vent hoods and purge systems, and then there's an auxiliary central system for evacuating or exhausting the entire volume of air in the building. The quantities of the gasses that are used in the experiments are very small, and in using those with a high volume of air and the distillation of it, they are vented directly to the atmosphere. And we operate under the State of Maryland EPA requirements and OSHA requirements, and we have not had any problems in the past. We don't anticipate any with this one.

Mr. **Nelson**. The Numerical Aerodynamics Simulation Facility at Ames—it increased $3.2 million. Why did we have a change in the ENR construction cost index for that type of work? And it occurred during a 1-year deferral. What's the present status of this project and the scheduled completion date?

General **McGarvey**. All right, sir, let me address the cost elements of it.

First of all, as you recall, last year the request was reduced by $5 million, from $16.5 to $11.5 million, which was authorized and appropriated. And we were asked to reschedule or rephase the construction in order that it could be completed in 1986. We have done that; and in doing that, of course, we have incurred some additional costs of having to stretch it out and rephase it, and ensure that with funds available, the $11.5 million that was appropriated in 1985, that we got a closed-in building shell with the basic systems in order that we didn't just construct up to a point and then have to stand the contractor down until we got 1986 funds to complete it.

We estimated the cost escalation over the range of the impact to the entire $16.5 million facility, and we increased that by 3.6 percent, or the $600,000. So there's a $600,000 increase for escalation applied to the entire project—not to just the $5 million increment, but to the $16.5 million.

Further, we have, in advertising it and awarding the construction contract, we advertised the complete facility, the entire facility. And in the marketplace, based on the bids—and we had some very competitive bids, and have a good construction contractor under contract, the Perine Corp. out of Massachusetts, that was the successful bidder—bears out that that cost was a reasonable cost escalation factor. We have a contingency of only about 7 percent to complete the job where we'd normally have about a 10-percent contingency.

The other element that drove the cost up was that at the time we submitted the project last year, in 1985, we had under consideration a requirement to provide secure data processing at a level that would permit us to process data that was accessed to us from the Department of Defense, and data that we needed or would turn out ourselves which would be usable to DOD. And this, in turn, has caused an increase of $2.6 million to provide a secure data processing area in one portion of the building. And when you add those together, the $5 million, the $6 million, and the $2.6 million, that accounts for the $3.2 million increase.

As to the completion date, the building is under construction with a completion date, minus the secure area, to be completed in December 1986. To provide the security modification areas, we would initiate that construction in February of 1986, and it would also be completed in December of 1986 if we get sufficient funds to carry that out.

Mr. NELSON. Just a couple more questions.

Down at KSC you have this orbiter modification and refurbishment facility. Now, is it possible at a later date that you could—if you really started cranking up flight schedules—that you could use it in the actual processing flow?

General McGARVEY. The building is being designed, the facility is being designed to have the identical configuration of a high-bay processing facility, similar to the existing orbiter processing facility, so that in the future—and it has all the basic utilities, the same as the existing facility has, including air conditioning, in the $14 million request—but in the future, if the flight rate demands it and requires a third processing facility to support that flight rate, it could be fleshed out by adding the additional work stands and the additional orbiter-peculiar equipment that's normally—the bulk of that's normally funded from the R&D side of the house; we would require, probably, another $12 million to $14 million in facility mods, and then there would be a significant requirement for equipment and orbiter-peculiar equipment to go with it from the R&D

account. But it could be outfitted, and it's being designed that, if that should come about, we could do that.

Mr. NELSON. OK. Mr. Nysmith, could you come back up? Is he still here?

Can you come up? I want to ask you one more question.

NASA has been very fortunate to have the cream of the crop over the years of the Federal civilian workforce. They've been very fortunate. And we've been able to retain them quite well. I meant to mention this to you, and I haven't had a chance to. But as I had been moving around the Centers, I'm starting to see a morale problem out there, and some of the Center Directors are telling me that they're starting to be concerned about being able to hold their best people. And one example that they give to me is the present proposal in the budget, that you take the last 5 years and average for purposes of retirement, instead of the present law, which is the last 3 years. Some of this expression of opinion has been that they're afraid that they're going—that these people are going to take early retirement because they're afraid that if the proposal of the last 5 years would take effect, that it will knock their retirement considerably down. So they are not willing—some of them are expressing that they're not willing to take that risk, that the 5-year part is not going to be enacted.

You're the personnel guy; what's going on out there?

Mr. NYSMITH. Well, I think you've hit on a real problem. We're very concerned about it. The proposals that are being talked about in regard to changes in the retirement system, which is really what you're talking about, and that's one element of it—other elements are raising the age from 55 to 65, and whatever—that's a real concern to us because it is affecting morale. Now, we haven't gone to the trouble of trying to track productivity decreases, but people spend a lot of time worrying about it. We have, in fact, been looking at our work force makeup, seeing what kind of a problem we may well have. And we, as you would imagine, because of the makeup of our work force, where we were in a declining civil service ceiling for about the past, almost, 10 years up until the last couple of years, where we've finally stabilized, we have a work force that has a lot of people between the ages of 40 and 50, particularly between the ages of 45 and 50, which is where your key managers are. And these are the people who are at your critical level; they're the next Center Directors, or maybe they are Center Directors—some are—but they're high level. Most of them can get another job on the outside that in fact will pay them more than they're getting now, and they've always felt—you know, that in staying with the Government, staying with NASA, they are able to do work that they really love to do and they want to do. But now, when you change the system and start saying, well, you are not going to be able to retire at age 55, but 65, and your retirement is going to be based on high 5 instead of high 3—we may have already had our high 3, if they keep the 5-percent pay reductions going through—but if you make these kinds of changes, people look at where they are, their positions, they think about their families and what does it mean.

My real concern, my personal concern, and I've talked to the Center Directors and we've actually had them all together to talk about our problems—their concern is that if some of these changes happen, we may get a mass exodus. And I don't know what we can do about it. I don't think there is any—we're trying to do other things. I talked about R&PM in training and development; this is an item where it helps keep people more happy, but I think it is a real concern. I think it really bothers very, very many of us.

Mr. **Nelson**. Is it specifically the high 5 versus high 3? Is it the restraints on increases, the 5-percent cut that you're talking about? What is it? Is it an accumulation of these things, or are there other things as well?

Mr. **Nysmith**. I think the biggest concern to most people is if they were to change the retirement age.

Mr. **Nelson**. The retirement age?

Mr. **Nysmith**. The retirement age, which is from 55 to 65. That's the one that suddenly——

Mr. **Nelson**. Is that actually a proposal to the Congress?

Mr. **Nysmith**. That's one of the proposals.

Mr. **Nelson**. I see.

Mr. **Nysmith**. And that is a big, big change because there are guys who have put in a career of, up to this point in time, 20 years, and now you change the ground rules. Now, that really bothers them. The high 5 or high 3 bothers a smaller set of people, but they are the ones between ages—who are getting near retirement, and it means as much as $200 to $300 a month in a person's retirement. So that's the next level down.

But one of the biggest problems has been the overall negative effect of the proposal for changes in the retirement system, 5-percent pay cut, the general rhetoric about the civil servant in general and the Federal bureaucrat—it's a negative factor.

Mr. **Nelson**. Do you know, in that proposal, is there any provision for grandfathering?

Mr. **Nysmith**. Yes; there is. There is provision for grandfathering, particularly with the age; but the people that I'm talking about, between the ages of—well, near 50, would be grandfathered in, but the penalty is very, very large. A person at the age of 50, as I recall the numbers, and I could actually give you a table that would show it, but for instance, their annuity would be reduced by a factor like 50 percent, because it raises—currently the penalty is something like 2 percent a year for every year you are under age 55. The penalty goes to like 5 percent a year, with some grandfathering in; but there's still a major penalty.

Mr. **Walker**. Mr. Chairman, if I could?

Mr. **Nelson**. Sure.

Mr. **Walker**. Just to build on this, the thing is, the administration's proposal is probably not going to be the proposal that flies on retirement. We are going to have to do something about retirement because, with the advent of Social Security for new hires, they're now in a position where, if they're trying to participate in both Federal retirement and in Social Security, they are being unfairly penalized, too. And so we have got to do something about that at the new entry level of the scale. So there's going to be some proposal on retirement.

If all of those things were to take place—in other words, we go to high 5, we go to age 65, and a lot of those things, for new entrants—would that cause any great problems with your present workforce? In other words, the ground rules that we establish would be different for people coming into the system than the ground rules that presently exist?

Mr. **Nysmith**. Yes.

Mr. **Walker**. In all honesty, I think that's where Congress is likely to end up in all of this. It might increase your problems in terms of getting new hires, who won't find the retirement system as attractive. On the other hand, I guess, the question is whether or not that's going to have any great impact in your present workforce.

Mr. **Nysmith**. I don't think anyone has any problem, and I think most NASA people would agree that the system—a change, as you talked about—is the right way to go for new hires and, in fact, I don't think people worry—there's a certain period of time at which you're vested into the system, you've vested your career. I think 10 years is not a problem; as a matter of fact, if people with 10 years or less experience were subjected to the new system, I don't think even they, with less than 10 years, would be bothered much. But it's once you get above—you know, about 15 years on up—you've really vested into it. So I don't think most of the people are concerned, and would be concerned, with changing the rules for new people. They'd probably think it's a positive thing.

Mr. **Walker**. So in other words, if you grandfather in everybody above the 10-year mark, or something like that, that probably wouldn't cause too much in the way of morale problems?

Mr. **Nysmith**. That would be my assessment.

Mr. **Walker**. What's been your experience when you have a lot of people leaving along the way? Do we lose our best people or our worst people?

Mr. **Nysmith**. Best people.

Mr. **Walker**. Best people?

Mr. **Nysmith**. Always the best people.

Mr. **Walker**. Thank you.

Mr. **Nelson**. May I recommend to you all that you ought to put together a presentation, because you're the jazzy agency of all Federal agencies—you're the one that, I imagine, if you did a study among all Federal agencies, you would find that you all have a higher retention than most—and I think that you ought to make a presentation to the committee that has jurisdiction over this subject. And I assume that would be Post Office and Civil Service. And I think you ought to make that presentation, and you ought to tell this story.

Mr. **Nysmith**. We can certainly do that.

Mr. **Walker**. And you all ought to let us know so that Bill and I can go sit in on that hearing when they have it. I recommend that you pursue that.

Mr. **Nysmith**. We have been pulling together the information that shows a fairly clear story. It's a clear story that worries us all, because the number of people we have at those critical levels is very large, and it bothers us. It worries us. We can put this story together.

Mr. **Walker**. If I may, can I raise this one point on the other side, however?

One of the reasons why NASA was able to achieve what it was able to achieve in the Moon Program and so on was that you brought together that new team. It was a new team with a lot of vigor to it, a lot of new ideas, and so on; you got a lot out of that. If, in fact, you went through what would be a very devastating experience for NASA, where you would lose a lot of people, is there a chance that you would also bring in a lot of people with a lot of new ideas and a lot of new concepts about where we ought to go on the projects of the future in a way that might drive the Agency ahead, rather than retard it?

Mr. **NYSMITH**. I think that what you're saying is a good thing. We don't have a real problem as long as you can bring in the people at the bottom, but we have that other problem. We have a very, very difficult time competing for the fresh-outs. And we have, by far, the easiest time of any of the other Federal agencies, I think. We can still attract people based on what we do, and they know us and are proud of being with NASA, and so we can bring them in. But we have seen our acceptance rate decreasing. You can't judge quality based on grade point average, but for instance when we make 20 offers and we get 10 acceptances, say, this year, and in the past when we made 20 offers we may have gotten 15 acceptances, this starts to give you an idea that, gee, you're not quite as attractive as you used to be.

So yes, we in fact like to have turnover. That's good for the Agency, but you do have to replenish at the bottom, and that's where we're concerned, because all of the factors about the Federal employee and the pay and the benefits and all that are making it more difficult for us to bring in those replacement people. And that's a problem.

Mr. **WALKER**. Thank you.

Mr. **NELSON**. If you could send us some of those statistics on your retention rate and your recruiting, et cetera, just amplify on what we're talking about here so we can go over it and understand it, and then we'll decide what we want to do, because NASA is a national asset for the United States and we can't take the risk that we have this place completely demoralized. And yet, we have to judge all of this within the fiscal realities of the tightening that's going to have to be done. So I think we'd better start paying some attention to this.

Mr. **NYSMITH**. Well, we'll do that. And I thank you for your interest, and I know that the Center Directors and the other management will be heartened by your interest.

Mr. **NELSON**. Why don't you send this word out and, in this report you send back to us, send any of the comments from the Center Directors?

Mr. **NYSMITH**. I'll do that.

Mr. **NELSON**. Because I've talked to 3 or 4 of them, and we have more than that, and I would like to have the benefit of the rest of them.

Mr. **NYSMITH**. I could even have some of them come in here and talk to you or some of your people about the problems they really face out there. You know, we get it second hand here in Washington.

[The information follows:]

Because of our inability to match private sector salaries the decline in the rate of acceptance of NASA offers of employment by recent engineering graduates (GS-5 thru 12) has been rather dramatic.

	Percent
1984	33.3
1983 [1]	56
1982	48
1981	62

[1] The temporary increase in 1983 is attributable to the economic recession.

Following are differences in average 1984 starting salary offers:

	NASA	Industry	Difference
Bachelor of science	$22,287	$26,000	$3,613
Master of science	25,980	29,000	3,020

In some cases the difference is much higher.

Examples: ARC—White female PhD; NASA offer $31,619; Varian Associates offer $43,000.

Asian male MS Electrical Engineering (Stanford); NASA offer $25,900; Lockheed offer $37,000.

White male BS Electrical Engineering; NASA offer $23,170; IBM offer $28,500.

JSC—Minority male MS Mechanical Engineering; NASA offer $25,980; Three industry offers: ATT $34,500; Aerospace Corporation $33,020; Sandia Labs $32,200.

MS Aerospace Engineering; NASA offer $25,980; Three industry offers: General Dynamics $32,600; Dupont $32,800; Westinghouse $30,600.

Female Co-op BS Aerospace Engineering; NASA offer $23,170; Industry offer $30,000.

KSC—Minority male Electrical Engineering, Co-op since 1981, Florida Institute of Technology; NASA offer $18,710 (not eligible for GS-7); Martin Marietta offer $28,000 plus 5% after 90 days.

MSFC—NASA offer to nonminority female Mechanical Engineering from University of Iowa $23,170; Industry offer (accepted) $35,000.

Mr. NELSON. Last question.

General McGarvey, can you tell me anything about KSC's proposed facility for liquid oxygen and liquid hydrogen?

General McGARVEY. Yes, sir. This is, in our terminology, the proposed polygeneration plant to produce a primary product, being liquid hydrogen, liquid oxygen, and gaseous nitrogen; and, at the same time, cogenerate electricity for augmenting the electrical power at the Center. That proposal has been staffed and briefed through the headquarters now, and a solicitation for interest by the private sector was published on, I believe, February 26 in the Commerce Business Daily, where Kennedy has solicited an expression of interest from the private sector, people who would be interested in undertaking such an activity, to be located on the Kennedy Space Center in an area fairly close to Launch Complex 39, to the launch areas, on the basis that it would be fully financed by the private sector and the technical risk associated with it would have to be taken by the private sector. They have, I believe—I was trying to recall the dates—I believe the announcement called for a formalizing of the requirement by the 8th of March, and giving those people 6 weeks, or until the 19th of April, to respond so that by the 19th of April we should have responses back from the private sector as to the interest. And at that point, then NASA will have to decide collectively whether it's a cost-effective and beneficial venture for us to undertake that with those people.

Mr. **Nelson**. OK. When you get to making those decisions, will you come in and brief me personally on it?

General **McGarvey**. Yes, sir. I'd be happy to.

Mr. **Nelson**. I appreciate it. Whomever—you, or whomever you designate would be fine.

General **McGarvey**. All right, sir.

Mr. **Nelson**. OK. Any more questions?

[No response.]

Mr. **Nelson**. All right. Thank you. We'll reconvene tomorrow for our next hearing.

[Whereupon, at 11:32 a.m., the subcommittees recessed, to reconvene at the call of the Chair.]

1986 NASA AUTHORIZATION

THURSDAY, MARCH 7, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met, pursuant to notice, at 10:03 a.m., in room 2318, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Present: Representatives Nelson, Brown, Volkmer, and Torricelli.

Mr. Nelson. Good morning. The subcommittee will now come to order.

We are just delighted to have our friend from the European Space Agency here this morning, Prof. Reimar Lüst, Director General of ESA. We are going to continue our 1986 authorization hearings focusing on the cooperative activities that NASA has with other key governmental agencies, and one of our most important international partners. We are going to be hearing during this entire session this morning from Dr. Lüst and his colleagues, as well as the Air Force and the Department of Transportation.

It's a privilege to have you, Professor Lüst. The close cooperation between the United States and the European space communities for over 20 years exemplifies the role that joint space exploration can play in furthering the understanding of the space environment for the benefit of all mankind.

And certainly, beyond that, the fact that ours has been a true partnership has opened up all new vistas of understanding across political international boundaries. Both sides have benefited from these early cooperative efforts, like the launching of the SRO scientific satellites in 1968 to the more recent spectacular success of spacelab I mission.

The design and construction of spacelab by ESA is a stunning achievement that clearly demonstrates the Europeans' capability in manned space projects. And all of us look forward to the next two spacelab missions set for later this year.

As we enter now this exciting space station era, we're delighted that our European partners have voted to play a major role in this unique and exciting project.

Professor Lüst, we welcome you to the Subcommittee on Space Science and Applications, and we look forward to hearing from you today. Later on I will be introducing our other guests that will be with us.

May I say that there were a lot of folks, some skeptics and cynics in the world, who didn't think that there could be a major international venture. They thought, "Well, spacelab, that's one thing, but a whole big space station, how can you ever get past all of the eccentricities and differences that international boundaries cause." And yet, it's being overcome, and it's being overcome daily because of a commitment for the joint international exploration of the unknown.

So we welcome you, Professor. We are delighted to hear your testimony.

And may I say, my ranking member, Bob Walker, is tied up in a meeting right now. He will be here just as soon as he can be, and indeed the entire Republican part of this committee, they are all in the same meeting, and without objection we will enter into the record Bob Walker's opening statement.

[The prepared opening statement of Mr. Walker follows:]

OPENING STATEMENT FOR
HON. ROBERT S. WALKER
SSA SUBCOMMITTEE HEARING
MARCH 7, 1985

GOOD MORNING, MR. CHAIRMAN. I AM LOOKING FORWARD TO HEARING OUR WITNESSES THIS MORNING.

FOR THE PAST FEW WEEKS, THIS SUBCOMMITTEE HAS BEEN WRESTLING WITH A NUMBER OF SERIOUS PROBLEMS WHICH ARE CRUCIAL TO THIS NATION'S FUTURE IN SPACE.

THE TWO MOST CRITICAL PROBLEMS INVOLVE OUR FUTURE PRICING POLICIES FOR THE SPACE SHUTTLE AND THE VIABILITY OF THE EXPENDABLE LAUNCH VEHICLE INDUSTRY, BOTH DOMESTIC AND INTERNATIONAL.

TODAY WE WELCOME PROFESSOR REIMAR LUEST, THE DIRECTOR GENERAL OF THE EUROPEAN SPACE AGENCY. PROFESSOR LUEST IS A FRIEND, AN ALLY AND A COMPETITOR. HIS AGENCY REPRESENTS ELEVEN MEMBER NATIONS WHICH HAVE ALREADY MADE SIGNIFICANT COMMITMENTS TO OUR FUTURE IN SPACE.

WHILE WE ARE ENGAGED IN A CLEAR COMPETITION WITH ESA FOR THE PROVISION OF LAUNCH SERVICES ON ARIANE OR OUR SHUTTLE, WE ARE ALSO ALLIES AND PARTNERS IN A NUMBER OF AREAS.

WE STRONGLY VALUE PAST AND PRESENT EUROPEAN COOPERATION IN MAJOR

JOINT EFFORTS SUCH AS SUPPORT FOR THE UPCOMING GIOTTO-HALLEYS COMET ENCOUNTER AND THE ULYSSES SOLAR POLAR MISSIONS. THE EUROPEAN DEVELOPMENT OF SPACELAB AND ELEMENTS OF THE HUBBLE SPACE TELESCOPE MARK MAJOR CONTRIBUTIONS TO OUR SPACE EFFORTS.

AS WE APPROACH THE 500TH ANNIVERSARY OF THE EPIC VOYAGE OF DISCOVERY OF CHRISTOPHER COLUMBUS WHICH BROUGHT OUR EUROPEAN ANCESTORS TO A NEW WORLD TO EXPLORE AND EXPLOIT, IT IS OUR PLEASURE TO WELCOME OUR EUROPEAN PARTNERS TO THE SPACE STATION PROJECT WHICH WILL MARK THE GREATEST PERMANENT EXPANSION OF OUR COMMERCIAL AND SCIENTIFIC WORLD SINCE 1492.

WE ALSO WELCOME AIR FORCE UNDERSECRETARY PETE ALDRIDGE WHO IS ALREADY WELL KNOWN TO THIS COMMITTEE. WE WILL OBVIOUSLY HAVE A NUMBER OF QUESTIONS ABOUT THE RECENT DEPARTMENT OF DEFENSE DECISION TO COMMIT TEN PAYLOADS TO EXPENDABLE LAUNCH VEHICLES IN THE 1988-1992 TIME FRAME.

WE ARE ALSO INTERESTED IN THE STATUS OF THE LAUNCH FACILITIES AT VANDENBERG SINCE WE ARE RAPIDLY APPROACHING OPERATIONAL CAPABILITY FROM THE WESTERN TEST RANGE.

FINALLY, WE WELCOME JENNA DORN FROM THE DEPARTMENT OF TRANSPORTATION OFFICE OF COMMERCIAL SPACE TRANSPORTATION. THIS IS HER SECOND APPEARANCE BEFORE THE SUBCOMMITTEE IN UNDER THREE DAYS. IN HER LAST APPEARANCE, SHE PUT UP A SPIRITED DEFENSE OF OUR DOMESTIC ELV INDUSTRY. WE SEE A SPACE FUTURE INTO THE 1990'S AND BEYOND BASED ON REGULAR ACCESS TO SPACE ON BOTH THE SHUTTLE AND AN AGGRESSIVE ELV INDUSTRY. IT IS OUR HOPE THAT WE WILL BE ABLE TO DEVELOP POLICIES WHICH WILL INSURE THAT FUTURE.

Mr. NELSON. Professor Lüst, please proceed with your statement.

STATEMENT OF PROF. REIMAR LÜST, DIRECTOR GENERAL, EUROPEAN SPACE AGENCY, ACCOMPANIED BY GEORGE VAN REETH, DIRECTOR OF ADMINISTRATION; JEAN ARETS; AND IAN PRYKE

Mr. LÜST. Mr. Chairman, members of the subcommittee, first of all let me thank you very much for the invitation that you have extended to the European Space Agency's testifying once again because of your deliberations of the NASA budget request. But I would like to thank you also very much for your kind words at the beginning of the session.

First I would like to introduce my colleagues here at the table: Mr. Van Reeth, Director of Administration for a long time of our agency; then Mr. Arets of our international office; and I believe everybody knows here Mr. Pryke, the head of our branch here in Washington.

Mr. NELSON. And I might say, Professor, I look forward to a visit we are trying to plan to the ESA headquarters later on this year by the subcommittee, and we will look forward to that continued building of our friendship with you.

Mr. LÜST. Well, thank you very much for this very good news. You are most welcome in Paris and headquarters, but also in any other establishment of our agency.

Mr. Chairman, I will not read the full statement which I have prepared in writing. I will present a condensed version and then, of course, I am very pleased to give you answers to all questions if I am in a position to give answers.

Let me state at the start, last year we celebrated two decades of European cooperation in space, and throughout that period, cooperating with the United States has been an important component in many of our programs. And we have every expectation that this will continue to be the case in the future.

In order to put my testimony in the correct context, I think it might be helpful if I give a short summary of the outcome of a recent meeting of our council on the ministerial level which took place at the end of January in Rome and which got quite large coverage in the press in Europe.

At the start of the meeting the ministers noted Europe's achievements in the space field over the last 20 years, and besides successfully carrying out large numbers of scientific and application satellites, Europe has acquired a program for independent and competitive launch capability and now has all the access to manned space flight technology through the construction and flight of spacelab, which you have mentioned.

And taking into consideration that first the launch programs decided in 1973 have now been successfully completed by ESA, and second, that the new long-term program for space activities have been proposed, and, this was a very important point, the President of the United States has been invited to participate in the space station program.

The ministers in Rome recognized that the present scope of the agency's program had to be enlarged within a coherent and a complete and a balanced long-term program to meet the challenges of the next decade and beyond. And the main aims of this policy for the envisaged periods unto the year 2000, one might say, are to expand Europe's autonomous capability and Europe's competitiveness in all sectors of space but as well to enhance and strengthen the partnership with the United States.

And with this in mind, the ministers approved a number of decisions that are described in the Council Resolution on the Long-Term Space Plan and also in the Resolution on Participation of the Space Station Program. And these two resolutions, Mr. Chairman, are annexed to my written statement.

I believe of particular interest to the subcommittee is the fact that through the resolutions the Council welcomes and accepts the offer by the President of the United States of America to participate in the space station, with a view to continuing and strengthening again the partnership in space fields, I should add, subject to the achievement of fundamental objectives listed in the resolution attached.

Second, the Council welcomes and endorses the proposal to undertake the Columbus Program as a significant part of the International Space Station Program.

As to other key decisions that are related to science, the scientific program will be increased in quite a remarkable way, applications and transportations. And this is the ministers' recognizing that the implementation of the plan as a whole and as approved would require a substantial increase in the agency's financial resources through the end of the decade, and the increase will be more than 50 percent of the present budget, total budget, of the agency.

I believe that I can sum up that the ESA Council of Ministers of the members states of ESA have shown that the European states share a common vision of Europe's future in space and that they are in the political resolve to enable Europe to improve its already strong position among the field of space powers.

And with this in mind, Mr. Chairman, I will now address specific issues of the cooperation, starting with the space station.

For about 3 years, ESA has carried out certain spacelab follow-on development studies. One result of these studies was a decision to build EURECA. "EURECA" stands for a free-flying vehicle to be placed in orbit by the shuttle, hopefully in the year 1988.

Another study in relation to the space station was undertaken by the Germans, by the Italian Government, and more recently a further study by the British Government. The objective of these studies was to prepare Europe's role in building the space station elements. And as I have said earlier in my first remarks, the ESA Council welcomes and accepted the invitation by the President of the United States.

But it also stated that it accepted the U.S. offer subject to the achievement of some fundamental objectives, such as European responsibility for design, development, exploitation, and management of one or several, I would say, identifiable elements of the space station. Furthermore, under the condition that Europe has access to and use of all elements of the space station on a nondiscriminatory basis and under the condition such as the agreement on the sharing of the operating costs and on the extent and conditions for the appropriate technology transfer can be achieved.

But I should close this part that I am very confident that this can be achieved, since the negotiation between ESA and NASA on the space station phase B, which will be started very soon, or already has started, as MAU has almost completed, and my impression is that both sides are satisfied.

But, of course, the discussion for the basic principles to be included in an agreement which will not be a MOU but which should have more legal force and should be more a legal instrument have to be started very soon for the phases A, C, E, and D.

Let me now come to spacelab very shortly. It will be recalled that Spacelab is Europe's contribution to the United States space transportation system. As you stated, Mr. Chairman, the first flight took place over the period of November 28 to December 8 last year, and was recognized to a very large extent in the public all over Europe. The flight was somewhat later than it was anticipated, and therefore not all experiments had the optimum condition. But we were pleased that NASA has agreed to fly these experiments on later flights.

I would like to mention in particular the spacelab flight which is called number 2, but which is actually number 3, scheduled for launch in July 1985. It will use for the first time only the configuration of the pellets and of the so-called "igloo," and it will make use for the first time of the instrument pointing system which had been fully developed by ESA and has been also fully paid by ESA in connection with the agreement for spacelab.

Let me now turn the attention to space science. In the field of space science, ESA and NASA have cooperated practically from the beginning. And I should say I personally at the beginning of the 1960's was very much involved in this. We happen to be following the present program of the international ultraviolet experiment, IUE, a very successful program.

We have the International Sun-Earth Explorer Program, where ESA has ISEE-2, and this program continues. We have as an ESA satellite the Exosat, an x-ray satellite, which was launched in the year 1983 by a Delta rocket. But until the end of February 1986 U.S. scientists have been allocated by almost 9 percent of the observing time.

And I hope very much that in 1986 the program formerly named the ISPM will be launched by the shuttle. Here I should draw the attention of your committee, Mr. Chairman, that there have been some problems; namely, due to the requirement of the U.S. Government to look for the possibility to add a protective shield due to the thermal generator which is included in the spacecraft, and this situation has created some concern in Europe.

But my very recent discussion with the NASA administrator indicated that this issue can be resolved without an impact on delay of the launch in 1986, and it now seems highly probable that no shield is needed. But, of course, we will be closely monitoring the process until it is absolutely clear that we can go ahead in this way.

The next spacecraft that I should mention that we are cooperating in is the Hubble space telescope, which is scheduled for mid'-

1986, and ESA is providing two instruments in the focal plane and the solar panel. And ESA is also complementing the staff of the Space Science and Space Telescope Institute in Baltimore. In addition, ESA has a coordinating facility in Europe, located in Munich.

I should also mention the Giotto spacecraft, which should be launched July 2 of this year. The Giotto spacecraft is designed to have a near encounter with Comet Halley by March next year. But also this is a program where we are closely cooperating with the United States and its many scientists of this country.

The next ESA program which is on schedule is the astronomical satellite called Hipparcos, to be launched in 1988, and from the 209 proposals for using this instrument, 25 have come from the United States.

And finally, I should close this list, that we are planning an infrared astronomy satellite. We just went under the process of selecting five mission scientists. One of the mission scientists which had been elected is an American.

In closing this part, I would like to draw your attention to the so-called solar terrestrial physics program, the so-called ISTP. There we are somewhat concerned with respect to our cooperation, since this is a cooperative project between the United States, Europe, and Japan. Due to our positive outcome of the ministerial conference, we are now ready to take decisions by the end of the year. And this is a necessity from our program in order that we can spend the necessary money, which we have now available. As far as I know, the Japanese are also ready, but so far this has not been included in the foreseen budget for 1986. So we hope that there will be no delay in that desynchronous action which had been taking place so far can be continued so that we have really a continuous program also in this area.

I should report very shortly on the application program. And there is a program likely to interest your subcommittee. This is the European remote sensing satellite called Earth-1, which is destinated for ocean and coastal zone monitoring. It should be launched in the year 1989, and ESA has received from NASA a request to receive synthetic aperature radar data at the station at Fairbanks. And I am very optimistic that appropriate budget for ESA will give very clear positive answer to this respect.

And also, NOAA is interested in the reception of low-bit-rate data from Fairbanks, and this is also studied in the moment.

Mr. Chairman, like my predecessors in previous years, I should now provide the subcommittee with some information on ESA's program which is not a feature of cooperation with the United States. And as you know, ESA has a responsibility for the development program for launcher, the responsibility for manufacturing, for the marketing, and for launching of operational Ariane launchers has been entrusted to a private firm called Arianespace.

The development and the qualification of Ariane 1 was completed in 1981, and Ariane 1 is in operation. The Ariane 3 launcher is an improved version of the initial Ariane 1 vehicle, just increasing the launch capability.

The development of the Ariane 4 version of the launcher is progressing to plan. Ariane 4 is a modular approach to an expanded launch vehicle concept, which will permit the launcher to be adapted to different payload combinations. It's foreseen that this launcher, the Ariane 4, to become progressively replacing the Ariane 3. And this launcher Ariane 3 should be finally phased out approximately in the year 1988-89.

In 1984 a preliminary decision was taken to initiate the development of a large new cryogenic engine, called in Europe HM60, which would equip the future launch organization, which will be called Ariane 5. At the ministerial meetings, the Ministerial Council in Rome has decided to go ahead with the development of the Ariane 5 launcher, which should be operational in the year 1985.

I should add that the Ariane 5 launcher will be designed as to allow a subsecond main rating, a fuel implementing decision on the Ariane 5 in the development program will be expected synchronous with the final decision to go ahead after phase B for the space station.

Europe has expressed an interest in the studies undertaken by France on the so-called Harness space plan. Also, this project is not for the time being an approved-ESA project. We will initiate studies within the agency and hoping to reach a conclusion for including this program not later by the year 1987-88.

And for explanation, I should say this spaceplane could have its first flight in the year 1998. It would be launched from the manrated Ariane 5 and could then have all the access, provide access for Europe to the space station.

Finally, before I conclude, I would like to say a few words on the commercialization of the Ariane launcher vehicle, which is discussed, I believe, here in the United States and also in Europe. As you know, the European member states and ESA have entered into consultation with the U.S. Government, represented by the U.S. Trade Representative on the pricing policy for launch services on both sides of the Atlantic. These consultations are of confidential nature, and I do not want to enter into any detailed review of this issue here.

In Europe, the provision of Ariane launch services has been fully commercialized. We entrusted these activities to a private company, as I said, to Arianespace.

The success in the commercial market has been considerable, due to the well-conceived and still relatively simple system, systematic use of dual launches and, I believe, by the precision of injection into orbit and, last, not least, on a reasonable pricing for an effective commercial approach and favorable economic conditions, much more than through governmental assistance than often alleged here in the United States.

However, as U.S. companies engaged in privatization expendable launch vehicles have also found out, Arianespace has great difficulties in competing in a market with the shuttle that's being priced without constraints that the commercial operator is normally subject to. Our concern is that while NASA has been instructed by presidential directive to develop a phase 3 pricing policy on the basis of full cost recovery, certain major cost elements continue not to be included in determining the price structure of the users, and so resulting in continued heavy subsidizing of shuttle operations by the U.S. Government.

We understand that the shuttle is considered as a national asset in the United States. We are obviously interested in its success, since we are also shuttle users on the European side. However, we hope that the United States will also understand that in Europe Ariane is simply considered as an essential part of our space policy and that European governments, while hoping to ensure a healthy competition between all launcher systems by minimizing the extent of any governmental assistance, will not let this asset to be jeopardized by an absence of reasonable commercial market conditions.

Mr. Chairman, in my testimony I have endeavored to comply with your invitation to comment on the current status of an outlook for cooperation with the United States on the space station, which I have placed into the context of the results of our ministerial meeting in Rome.

Furthermore, I tried to give you an overview on the status of the U.S.-ESA cooperation. And finally, I tried to express concern about the question of healthy competition between U.S. and European launch systems.

I think all these various facets are an expression of the fact that ESA and its member states remain dedicated to the cooperation with the United States in areas susceptible to cooperation.

But I should add also that we are looking forward for healthy conditions for competition in areas susceptible to competition. Europe has become an entity seriously, and we believe valid, partner for cooperation with the United States, thanks to the resolve of the European governments to increase their efforts so as to allow ESA to implement the crew here and complement the imbalanced crew.

I should add that President Reagan's invitation to Europe to participate in the space station program has had a very positive impact in shaping also in achieving the agreement on the long-term program on ESA by the decision of ministers in Rome. And I would like to take this opportunity to formally acknowledge this important fact.

In conclusion, Mr. Chairman, I would like to express my sincere thanks to the United States and especially to NASA for the very fine collaboration for more than 20 years, which will constitute an excellent basis for the future.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Lüst follows:]

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

STATEMENT BY PROF. R. LÜST, DIRECTOR GENERAL

EUROPEAN SPACE AGENCY

7 MARCH 1985

MR CHAIRMAN, MEMBERS OF THE SUBCOMMITTEE,

FIRST LET ME THANK YOU FOR INVITING THE AGENCY TO TESTIFY ONCE AGAIN IN THE COURSE OF YOUR DELIBERATIONS ON NASA'S BUDGET REQUEST.

LAST YEAR WE CELEBRATED TWO DECADES OF EUROPEAN CO-OPERATION IN SPACE. THROUGHOUT THAT PERIOD, CO-OPERATING WITH THE U.S. HAS BEEN AN IMPORTANT COMPONENT IN MANY OF OUR PROGRAMMES AND WE HAVE EVERY EXPECTATION THAT THIS WILL CONTINUE TO BE THE CASE IN THE FUTURE.

IN ORDER TO PUT MY TESTIMONY IN THE CORRECT CONTEXT I WILL FIRST SUMMARISE THE OUTCOME OF THE RECENT MEETING, AT MINISTERIAL LEVEL, OF THE ESA COUNCIL (ROME, 30 AND 31 JANUARY).

AT THE START OF THE MEETING THE MINISTERS NOTED EUROPE'S IMPRESSIVE ACHIEVEMENTS IN THE SPACE FIELD OVER THE LAST 20 YEARS. BESIDES SUCCESSFULLY CARRYING OUT A LARGE NUMBER OF SCIENTIFIC AND APPLICATION SATELLITE PROGRAMMES, EUROPE HAS ACQUIRED, THROUGH THE ARIANE PROGRAMME, AN INDEPENDENT AND COMPETITIVE LAUNCH CAPABILITY, AND NOW HAS ACCESS TO MANNED-SPACEFLIGHT TECHNOLOGY THROUGH THE CONSTRUCTION AND FLIGHT OF SPACELAB.

TAKING INTO CONSIDERATION THAT:

- THESE LARGE PROGRAMMES, DECIDED IN 1973, HAVE NOW BEEN SUCCESSFULLY COMPLETED,
- A NEW LONG-TERM PLAN FOR SPACE ACTIVITIES IN EUROPE HAS BEEN PROPOSED,
- THE PRESIDENT OF THE UNITED STATES HAS INVITED EUROPE TO PARTICIPATE IN THE SPACE STATION PROGRAMME,

THE MINISTERS RECOGNISED THAT THE PRESENT SCOPE OF THE AGENCY'S PROGRAMMES HAD TO BE ENLARGED WITHIN A COHERENT, COMPLETE AND BALANCED LONG-TERM EUROPEAN SPACE PLAN TO MEET THE CHALLENGES OF THE NEXT DECADE AND BEYOND. THE MAIN AIMS OF THE POLICY FOR THE ENVISAGED PERIOD ARE TO EXPAND EUROPE'S AUTONOMOUS CAPABILITY AND EUROPE'S COMPETITIVENESS IN ALL SECTORS OF SPACE ACTIVITY AS WELL AS TO ENHANCE AND TO STRENGTHEN THE PARTNERSHIP WITH THE UNITED STATES.

WITH THIS IN MIND THEY APPROVED A NUMBER OF DECISIONS THAT ARE DESCRIBED IN THE COUNCIL RESOLUTION ON THE LONG-TERM SPACE PLAN AND ON PARTICIPATION IN THE SPACE STATION PROGRAMME (BOTH ATTACHED AT ANNEX). OF PARTICULAR INTEREST TO THIS SUBCOMMITTEE IS THE FACT THAT, THROUGH THESE RESOLUTIONS, THE COUNCIL,

- WELCOMES AND ACCEPTS THE OFFER BY THE PRESIDENT OF THE UNITED STATES OF AMERICA TO PARTICIPATE IN THE SPACE STATION, WITH A VIEW TO CONTINUING AND STRENGTHENING A GENUINE PARTNERSHIP IN THE SPACE FIELD, SUBJECT TO THE ACHIEVEMENT OF FUNDAMENTAL OBJECTIVES LISTED IN THE RESOLUTION ON PARTICIPATION IN THE SPACE STATION PROGRAMME;
- WELCOMES AND ENDORSES THE PROPOSAL TO UNDERTAKE THE COLUMBUS PROGRAMME AS A SIGNIFICANT PART OF AN INTERNATIONAL SPACE STATION PROGRAMME.

OTHER KEY DECISIONS RELATED TO AREAS SUCH AS SCIENCE, APPLICATIONS AND

TRANSPORTATION, WITH THE MINISTERS RECOGNISING THAT THE IMPLEMENTATION OF THE PLAN AS A WHOLE AND AS APPROVED, WOULD REQUIRE A SUBSTANTIAL INCREASE IN THE AGENCY'S FINANCIAL RESOURCES, THROUGH TO THE END OF THE DECADE.

TO SUM UP, THE ESA COUNCIL, MEETING AT MINISTERIAL LEVEL, HAS SHOWN THAT THE EUROPEAN STATES SHARE A COMMON VISION OF EUROPE'S FUTURE IN SPACE AND THAT THERE IS POLITICAL RESOLVE TO ENABLE EUROPE TO IMPROVE ITS ALREADY STRONG POSITION AMONG THE WORLD SPACE POWERS.

WITH THE ABOVE IN MIND, I WILL NOW ADDRESS SPECIFIC ISSUES OF CO-OPERATION, STARTING WITH THE SPACE STATION.

SPACE STATION

FOR ABOUT THREE YEARS NOW ESA HAS CARRIED OUT CERTAIN SPACELAB FOLLOW-ON DEVELOPENT STUDIES. ONE RESULT OF THESE STUDIES WAS THE DECISION TO BUILD EURECA, A FREE-FLYING VEHICLE, TO BE PLACED IN ORBIT BY THE SHUTTLE. I WILL SPEAK ABOUT EURECA LATER.

ANOTHER STUDY WAS UNDERTAKEN BY THE GERMAN AND ITALIAN GOVERNMENTS AND, MORE RECENTLY, BY THE BRITISH GOVERMENT. THE OBJECTIVE WAS TO PREPARE EUROPE'S ROLE IN THE BUILDING OF SPACE STATION ELEMENTS. AS I HAVE ALREADY SAID IN MY INTRODUCTORY REMARKS, THE ESA COUNCIL, MEETING AT MINISTERIAL LEVEL, WELCOMED AND ACCEPTED THE US PRESIDENT'S INVITATION TO PARTICIPATE IN THE SPACE STATION. BUT IT ALSO STATED THAT IT ACCEPTED THE US OFFER SUBJECT TO THE ACHIEVEMENT OF SOME FUNDAMENTAL OBJECTIVES SUCH AS EUROPEAN RESPONSIBILITY FOR THE DESIGN, DEVELOPMENT, EXPLOITATION AND MANAGEMENT OF ONE OR SEVERAL IDENTIFIABLE ELEMENTS OF THE SPACE STATION, EUROPEAN ACCESS TO AND USE OF ALL THE SPACE-STATION-SYSTEM ELEMENTS ON A NON-DISCRIMINATORY BASIS, AND A SATISFACTORY AGREEMENT ON THE SHARING OF OPERATING COSTS AND ON THE EXTENT OF AND CONDITIONS FOR THE APPROPRIATE TECHNOLOGY TRANSFERS.

The negotiations between ESA and NASA on a Space Station Phase B MOU are nearing completion. Discussions of basic principles to be included in the legal instruments covering Phase C/D and E will have to start in mid1985.

One of the objectives underlying European participation is to broaden the horizon for space research and exploitation, master the new technology needed for carrying out manned and unmanned orbital operations in low earth orbit and thus permit the future development of a European in-orbit infrastructure.

ESA will run Space Station Phase B studies during 1985 and 1986 in parallel and in close cooperation with NASA's Phase B activities. We are currently planning studies for the development of a pressurised module, co-orbiting and polar-orbit platform(s), a resource module and a servicing vehicle. At the end of Phase B1, which will occur in late 1985, a decision will be made on those elements to be developed immediately and those to be developed later.

SPACELAB

It will be recalled that Spacelab is Europe's contribution to the US Space Transportation System.

The first flight, SL-1, took place over the period 28 November to 8 December 1983. This was later in the year than originally planned and because the lighting conditions were not good for four of the European experiments, they were guaranteed a free reflight. One of these experiments, the Very Wide Field Camera, will be aboard SL-3 to be launched in the Spring of this year. A second experiment has now been withdrawn but the other two - the Metric Camera and Grille Spectrometer - will be reflown on the Earth Observation Mission (EOM) set for late 1986. Two

Other European experiments concerned with solar observations, and the microwave radar facility will also fly on EOM together with the US-supplied payload elements.

The third Spacelab mission (SL-2) is scheduled for launch in July 1985. It will use the pallet only configuration for the first time - three pallets and an igloo. The latter is a pressurised cylinder containing essential subsystems that need a thermally controlled environment. This mission will also see the first flight of ESA's Instrument Pointing System (IPS) which is part of the Spacelab system and provides improved arc sec pointing of telescopes and other viewing instruments.

Another flight scheduled for later this year is the German D-1 mission which is devoted mainly to Material and Life Sciences. ESA is contributing significantly to this mission through its Biorack, Space Sled and Fluid Physics Module. Also, one of the flight Payload Specialists comes from ESA.

The exciting possibility of an International Microgravity Laboratory (IML) is currently under discussion. The first of three missions is scheduled for launch in late 1987. It will involve a Spacelab fitted out with Life Sciences and Material Sciences equipment provided by the participating organisations such as NASA, ESA, Japan and Canada. NASA will provide free launches in return for the use of any on-board equipment.

EURECA

With the European Retrievable Carrier system, EURECA, the European Space Agency will provide the User Community with the first European free-flying retrievable carrier for long-duration missions. This system, to be launched and retrieved by the Shuttle, improves the capabilities of

AVAILABLE REUSABLE SYSTEMS LIKE SPACELAB AND WILL THEREFORE FILL A GAP UNTIL THE SPACE STATION BECOMES AVAILABLE. THE SYSTEM HAS BEEN DESIGNED AS A MULTI-PURPOSE CARRIER WITH A DEDICATED PAYLOAD FOR A MICROGRAVITY MISSION DURING ITS FIRST FLIGHT. STUDIES TO DEFINE ITS UTILISATION FOR NON-MICROGRAVITY MISSIONS HAVE BEEN PERFORMED, WITH PROMISING RESULTS. JOINT NASA/ESA USE OF THE CARRIER FOR MICROGRAVITY, OTHER SCIENCES, APPLICATIONS AND TECHNOLOGY IS UNDER CONSIDERATION.

THE FIRST EURECA PAYLOAD CONSISTS MAINLY OF A "CORE PAYLOAD", WHICH IS DEVELOPED AND FUNDED BY ESA, CONSISTING OF FIVE FACILITIES DESIGNED SPECIFICALLY FOR EXPERIMENTS IN THE MICROGRAVITY ENVIRONMENT (MATERIALS AND LIFE SCIENCES). THE REST OF THE PAYLOAD CONSISTS OF SEPARATE MICROGRAVITY, SPACE SCIENCE AND TECHNOLOGICAL EXPERIMENTS.

AFTER THE FIRST MISSION SCHEDULED FOR EARLY 1988, WHEN THE EURECA FEATURES WILL BE DEMONSTRATED AND QUALIFIED, EURECA WILL TAKE ITS PLACE AS THE FORERUNNER OF A FIRST GENERATION OF SPACE PLATFORMS WHICH CAN BE USED FOR SPACE SCIENCE AND APPLICATIONS. IT REPRESENTS AN IDEAL TEST BED FOR IN-ORBIT TECHNOLOGY DEMONSTRATIONS (E.G. RENDEZ-VOUS AND DOCKING) WHICH ARE ESSENTIAL TO THE FUTURE SPACE STATION SCENARIO.

SPACE SCIENCE

IN THE FIELD OF SPACE SCIENCE ESA AND NASA ARE COOPERATING IN THE FOLLOWING PROGRAMMES :

- THE INTERNATIONAL ULTRAVIOLET EXPLORER, IUE, IS A VERY SUCCESSFUL PROGRAMME. THE EUROPEAN PARTNERS ARE WILLING TO CONTINUE THE OPERATION FOR AS LONG AS THE SATELLITE DATA PROVIDE SCIENTIFICALLY MEANINGFUL RESULTS.

- WITHIN THE INTERNATIONAL SUN EARTH EXPLORER PROGRAMME (ISEE) ESA'S SPACECRAFT ISEE-2 CONTINUES TO CARRY OUT OPERATIONS. IN ORDER TO HELP NASA ACQUIRE DATA ON SOLAR WINDS FROM ITS SATELLITE, IMP-8, AFTER ITS ISEE-3 SPACECRAFT, NOW RENAMED ICE, IS REDIRECTED FOR AN ENCOUNTER WITH COMET GIACCOBINI ZINNER, ESA WILL USE ITS REDU STATION. IN TURN, NASA WILL BEAR THE EQUIVALENT ESA COST OF THE ISEE-2 OPERATIONS.

- EXOSAT IS AN ESA X-RAY SATELLITE WHICH WAS LAUNCHED IN MAY 1983 BY A DELTA ROCKET. UNTIL THE END OF FEBRUARY 1986, US SCIENTISTS HAVE BEEN ALLOCATED 8.8% OF OBSERVATION TIME.

- 1986 SHOULD SEE THE SHUTTLE LAUNCH OF ULYSSES (FORMER NAME ISPM).

  A SERIOUS PROBLEM DEVELOPED RECENTLY WHEN THE US GOVERNMENT DECIDED TO ASSESS THE NEED TO PREVENT RADIOACTIVE CONTAMINATION FROM THE RTG (RADIOACTIVE THERMAL GENERATOR), WHICH MIGHT RESULT FROM A LAUNCH ACCIDENT. THE SITUATION CREATED EXTREME CONCERN IN EUROPE.

  MY RECENT DISCUSSIONS WITH THE NASA ADMINISTRATOR INDICATE THAT THIS ISSUE CAN BE RESOLVED WITHOUT IMPACT TO THE MAY 86 LAUNCH DATE, SINCE IT NOW SEEMS HIGHLY UNLIKELY THAT AN RTG BLAST SHIELD WILL PROVE NECESSARY. WE WILL OF COURSE BE CLOSELY MONITORING PROGRESS IN THE US ON THIS MATTER.

- THE HUBBLE SPACE TELESCOPE IS SCHEDULED FOR LAUNCH IN MID-1986. ESA IS PROVIDING A MAJOR FOCAL PLANE INSTRUMENT, THE FAINT OBJECT CAMERA (FOC), AND THE SOLAR PANELS AND IS CONTRIBUTING A COMPLEMENT OF 15 STAFF TO HELP WITH THE OPERATION OF THE ST SCIENCE INSTITUTE IN BALTIMORE. IN ADDITION, A EUROPEAN COORDINATION FACILITY, TO ASSIST

THE EUROPEAN ASTRONOMERS IN USING THE TELESCOPE DURING THEIR 15% SHARE OF OBSERVATION TIME, HAS BEEN SET UP IN THE EUROPEAN SOUTHERN OBSERVATORY, GARCHING (FRG). ALL STAFF ARE NOW IN POST.

THE FOC WAS DELIVERED TO LOCKHEED MISSILE & SPACE CO. ON 13 FEBRUARY 1985 AND ITS INTEGRATION WITHIN THE OPTICAL TELESCOPE ASSEMBLY IS TAKING PLACE AS FORESEEN.

WORK IS PROCEEDING NORMALLY ON THE SOLAR ARRAY FOLLOWING NASA'S REQUEST TO DEVELOP NEW BLANKETS WITH MORE POWER CAPABILITIES.

- GIOTTO IS THE NEXT ESA SCIENTIFIC PROJECT TO BE LAUNCHED (2 JULY 1985). ESA, NASA AND THE INTERNATIONAL HALLEY WATCH, TOGETHER WITH THE JAPANESE ISAS AND THE USSRS ACADEMY OF SCIENCES, FORM PART OF THE INTER-AGENCY COORDINATION GROUP WHOSE ROLE IS TO COORDINATE ALL RELEVANT SPACE MISSIONS, GROUND-BASED OBSERVATIONS AND DSN TRACKING. THE NEXT MEETING OF THE IACG IS SCHEDULED FOR 9 SEPTEMBER IN WASHINGTON ON THE OCCASION OF THE ICE ENCOUNTER WITH COMET GIACCOBINI ZINNER.

- HIPPARCOS, AN ASTROMETRY SATELLITE, WILL BE LAUNCHED IN 1988 ON AN ARIANE-3. OF A TOTAL OF 209 PROPOSALS FOR PREPARING THE INPUT CATALOGUE OF STARS TO BE MEASURED, 25 HAVE COME FROM THE US.

- ISO - THE INFRARED SPACE OBSERVATORY - WILL BE LAUNCHED IN 1992 ON EITHER AN ARIANE-3 OR AN ARIANE-4. ESA HAS JUST UNDERTAKEN THE SELECTION OF 5 MISSION SCIENTISTS, ONE OF WHOM IS AMERICAN.

THE FUTURE OF ESA'S SPACE SCIENCE PROGRAMME HAS BEEN CONFIRMED BY THE RECENT ENDORSEMENT BY THE MINISTERS IN ROME OF ESA'S LONG-TERM PLAN WHICH INCLUDES FOUR KEY AREAS OF INVESTIGATION. ONE OF THESE - THE SO-CALLED SOLAR TERRESTRIAL PHYSICS CORNERSTONE - IS TO BE PART OF A BROAD

International cooperation project between the US, Japan and Europe - the International Solar Terrestial Physics Programme ISTP. ESA would contribute two complementary satellites, Soho and Cluster, both with strong US involvement in terms of scientific instrumentation, launch and operations. ESA will decide on this "new start" in late 1985 and is somewhat concerned that NASA's FY 86 budget request does not include any provision for the ISTP. Should NASA fail to have its ISTP component(s) considered as a FY 87 new start, ESA will be forced to proceed with Soho and Cluster within a purely European context. From an international space science point of view we consider this would not be an optimum solution.

Apart from the ISTP, ESA and NASA are conducting joint studies in areas of potential cooperation relating to far ultraviolet stellar spectroscopy, far infrared and sub-millimeter astronomy, planetology (NASA building an Saturn orbiter and ESA a Titan atmospheric probe) and missions to comets and asteroids.

EARTH OBSERVATION

Turning now to applications, the programme likely to interest this Subcommittee most is the European Remote Sensing satellite ERS-1 destined for ocean and coastal zone monitoring. The States participating in ERS-1 have approved its development, manufacture, launch and exploitation phases (Phase C/D and E), and we are now in Phase C/D. The launch is planned for 1989.

ESA has received from NASA a request to receive Synthetic Aperture Radar (SAR) data at the latter's station in Fairbanks, Alaska. This request is currently being reviewed by the participating States and will eventually have to be approved unanimously by the ESA Council which it will hopefully do during the summer of this year.

NOAA is interested in the reception of low-bit-rate (LBR) data at Fairbanks. Studies on this are under way on both sides of the Atlantic.

With regard to a broader international context, it is worth mentioning the Committee on Earth Observation Satellites (CEOS). Its objective is to coordinate, where appropriate, the various earth observation spaceborne programmes under development or being planned by its members such as CCRS (Canada), CNES (France), INPE (Brazil), ISRO (India), NASA and NOAA, NASDA (Japan) and ESA.

Another forum for cooperation amongst partners of common concern is the "International Polar Orbiting Meteorological Satellite (IPOMS) group whose immediate objective is to provide international support for the US polar-orbiting meteorological satellites.

ARIANE

Like my predecessors in previous years, I will now provide this Subcommittee with some information on an ESA programme which is not a feature of cooperation with the US.

As you know, ESA has the responsibility for the development programme of the launcher. The responsibility for the manufacturing, marketing and launching of operational Ariane launchers has been entrusted to a private firm, ARIANESPACE.

Development and qualification of Ariane 1, was completed in 1981; the last two launches using this configuration will take place in 1985 with Giotto (an ESA probe to inspect Comet Halley) and SPOT (a French earth observation satellite).

The Ariane 3 launcher is an improved version of the initial Ariane 1 vehicle, increasing the launch capacity to 2600 kg (5800 lbs) in GTO.

Development of the Ariane 4 version of the launcher is progressing according to plan. Ariane 4 is a modular approach to the expendable launch vehicle (ELV) concept, which will permit the launcher to be adapted to the payload combination to be launched. To this end, 6 configurations can be flown by means of a core vehicle and a combination of up to 4 solid or liquid boosters, with a payload lift capability in GTO ranging from 2000 to 4200 kg (4400 to 9100 lbs). The demonstration flight, scheduled for 1986, will establish the Ariane 4 initial operation capability.

This launcher version is expected to progressively replace the AR3 version, which is expected to be phased out in 1988/89.

In 1984, a preliminary decision was taken to initiate the development of a new cryogenic engine, HM 60, which is to equip the future generation European launcher, Ariane 5. The ESA Council, at its meeting in Rome at Ministerial level, decided to go ahead with the development of the Ariane 5 launcher, which is planned to be operational by 1995. One of its prime objectives is to maintain European autonomy and competitivity in the field of launch services. The Ariane 5 launcher will be able to launch spacecraft of between 5.5 and 8 tonnes (12000 lbs to 18000 lbs) into GTO, and about 15 tonnes (33000 lbs) into LEO ; its shroud diameter will be compatible with the shuttle cargo bay, and a high design reliability will be the aim. The launcher will be designed so as to allow subsequent man-rating. A full implementing decision on the Ariane 5 development programme is expected in late 1986, together with a decision on European participation in the US Space Station.

Europe has expressed an interest in the studies undertaken by France on the Hermes spaceplane. Although this project is not for the time being an approved ESA programme, we will initiate studies together with the French authorities with a view reaching a conclusion at the latest, by 1987/88.

This spaceplane could have its first flight trial in 1998. It would be launched by a man-rated Ariane 5 launcher, and could put into LEO a payload of approx. 4500 kg (10000 lbs) ; its crew would consist of two pilots and up to four mission or payload specialists.

Finally, I would like to say a few words on the commercialization of the Ariane launch vehicle.

As you know, the European Member States and the ESA have entered into consultations with the U.S. Government, represented by the U.S. Trade Representative, on the pricing policies for launch services on both sides of the Atlantic. These consultations are of a confidential nature and I do not want to enter into a detailed review of the issues.

In Europe, the provision of Ariane launch services has been fully commercialized by entrusting these activities to a private company ARIANESPACE. The success in the commercial market has been considerable due to a well conceived and still relatively simple system, the systematic use of dual launches, the precision of injection into orbit and reasonable pricing through an effective commercial approach and favourable economic conditions, much more than through governmental assistance as often alleged in the U.S.

However, as U.S. companies engaged in privatizing expendable launch vehicles have also found out, ARIANESPACE has great difficulties in competing in a market where the Shuttle is being priced without the constraints that a commercial operator is normally subject to.

Our concern is that, whilst NASA has been instructed by Presidential Directive to develop a Phase III pricing policy on the basis of full-cost recovery, certain major cost elements continue not to be included in determining the price charged to users, thus resulting in continued heavy subsidising of Shuttle operations by the U.S. Government.

WE UNDERSTAND THAT THE SHUTTLE IS CONSIDERED A NATIONAL ASSET IN THE U.S. AND WE ARE OBVIOUSLY INTERESTED IN ITS SUCCESS SINCE WE ARE ALSO SHUTTLE USERS. HOWEVER, WE HOPE THE U.S. WILL ALSO UNDERSTAND THAT IN EUROPE ARIANE IS SIMILARLY CONSIDERED AN ESSENTIAL PART OF OUR SPACE POLICY, AND THAT EUROPEAN GOVERNMENTS, WHILE WISHING TO ENSURE HEALTHY COMPETITION BETWEEN ALL LAUNCHER SYSTEMS BY MINIMIZING THE EXTENT OF ANY GOVERNMENTAL ASSISTANCE, WILL NOT LET THIS ASSET TO BE JEOPARDIZED THROUGH THE ABSENCE OF REASONABLE COMMERCIAL MARKET CONDITIONS.

CONCLUSION

IN MY TESTIMONY I HAVE ENDEAVOURED, MR. CHAIRMAN, TO COMPLY WITH YOUR INVITATION TO COMMENT ON THE CURRENT STATUS OF AND OUTLOOK FOR CO-OPERATION WITH THE US ON THE SPACE STATION, WHICH I HAVE PLACED IN THE CONTEXT OF THE RESULTS OF THE ESA COUNCIL MEETING IN ROME. FURTHERMORE I HAVE GIVEN YOU AN OVERVIEW OF THE STATUS OF US - ESA COOPERATION. AND FINALLY, I HAVE EXPRESSED MY GRAVE CONCERN ABOUT THE QUESTION OF HEALTHY COMPETITION BETWEEN US AND EUROPEAN LAUNCHER SYSTEMS.

I THINK ALL THESE VARIOUS FACETS ARE AN EXPRESSION OF THE FACT THAT ESA AND ITS MEMBER STATES REMAIN DEDICATED TO COOPERATION WITH THE US IN AREAS SUSCEPTIBLE TO COOPERATION AND ARE LOOKING FOR HEALTHY CONDITIONS FOR COMPETITION IN AREAS SUSCEPTIBLE TO COMPETITION. EUROPE HAS BECOME AN INCREASINGLY SERIOUS AND VALID PARTNER FOR COOPERATION WITH THE US THANKS TO THE POLITICAL RESOLVE OF THE EUROPEAN GOVERNMENTS TO INCREASE THEIR EFFORTS SO AS TO ALLOW ESA TO IMPLEMENT A COHERENT, COMPLETE AND BALANCED LONG-TERM EUROPEAN SPACE PLAN TO COPE WITH THE CHALLENGES OF THE NEXT DECADE AND BEYOND.

PRESIDENT REAGAN'S INVITATION TO EUROPE, TO PARTICIPATE IN THE SPACE STATION PROGRAM, HAS HAD A VERY POSITIVE IMPACT IN SHAPING AND ACHIEVING THE AGREEMENT ON THE LONG TERM PROGRAMME OF ESA AND I WOULD LIKE TO TAKE THIS OPPORTUNITY TO FORMALLY ACKNOWLEDGE THIS FACT.

IN CONCLUSION I WOULD LIKE TO EXPRESS MY THANKS TO THE UNITED STATES AND ESPECIALLY TO NASA FOR THE HELP THEY HAVE GIVEN TO EUROPE AND FOR THE VERY FINE COLLABORATION FOR MORE THAN 20 YEARS, WHICH WILL CONSTITUTE AN EXCELLENT BASIS FOR THE FUTURE.

THANK YOU, MR. CHAIRMAN.

ESA/C-M/LXVII/Res.1 (Final)
4 February 1985 issue

EUROPEAN SPACE AGENCY

COUNCIL RESOLUTION
ON THE LONG-TERM EUROPEAN SPACE PLAN

(adopted on 31 January 1985)

The Council, meeting at ministerial level,

CONSIDERING that the Agency's activities and programmes have proved to be valuable to its Members and associated States and have contributed to satisfy the objectives assigned to the Agency by its Convention,

CONSIDERING the evolution in space activities and their fast expansion both in scope and volume throughout the world,

RECOGNIZING that the present scope of the overall Agency's programmes has to be enlarged within a coherent, complete and balanced long-term European space plan to cope with the challenges of the next decade and beyond,

CONSIDERING the offer made to Europe by the President of the United States to participate in the space station programme,

HAVING REGARD to the Director General's proposal on the long-term European space plan (ESA/C-M(85)2),

HAVING REGARD to the proposed level of resources to be made available to the Agency for the coming five-year period 1985-1989,

CHAPTER I
(Objectives)

REAFFIRMS its commitment to maintain and develop European independent capabilities in space.

AGREES to orient the European Space Programme:

- towards a coherent whole, in which the spending on the tools needed for space activities, and on the activities themselves, such as science and applications, are appropriately balanced: and

- to prepare autonomous European facilities for the support of man in space, for the transport of equipment and crews and for making use of low earth orbits;

- to enhance international cooperation and in particular aim at a partnership with the United States through a significant participation in an international space station.

CHAPTER II
(Programmes)

Taking into account the above mentioned objectives,

II.1 AGREES to a balanced long-term European space plan for the next decade along the lines proposed by the Director General leading to a comprehensive autonomous European capability in space and containing the following major elements: in-orbit infrastructure programme, space transportation systems programme and programmes for earth observation, telecommunications, microgravity, space science and technology.

II.2 WELCOMES and ENDORSES the proposal to undertake, as an optional programme in the field of in-orbit infrastructure, the Columbus programme, as a significant part of an international Space Station programme, as proposed by the United States of America; the Columbus programme, whose detailed content will be defined in the course of its preparatory phase and will also depend on the terms and conditions of the partnership agreement to be concluded with the United States, is at present estimated to cost 2600 MAU* until 1995 including a three-year period of operation and initial utilisation, and ENDORSES the agreement to undertake the Columbus Preparatory Programme.

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* all figures are expressed in 1984 economic conditions

i) earth observation, centered around the ERS-1 project already agreed and around future elements, i.e. the ERS-1 follow-on missions on oceanographic and meteorological applications, a land applications project, participation in the development of the second generation meteorological satellite and studies aiming at solid earth, atmospheric and climatology missions. The funding level for the earth observation activities would rise from 150 MAU in 1985 to a level corresponding to a yearly average of 190 MAU over the period 1985-95.

ii) space telecommunications, building on the achievements reached and centered around the development and the in-orbit testing of advanced payload systems. The funding level for the telecommunications activities would move from 180 MAU in 1985 to around 150 MAU over 1988-95, corresponding to a yearly average of 170 MAU.

iii) Microgravity, centered around an enhanced utilisation programme of Spacelab and Eureca leading to the utilisation of Columbus and the international space station for Microgravity R&D. The funding level for microgravity activities would increase from about 30 MAU in 1985 to 80 MAU per year over the period 1988-92, the funding for the following years being included in the Columbus programme.

II.7 AGREES, in order to reinforce in the next decade space science activities in Europe, progressively to increase the level of funding of the mandatory scientific programme to reach 162* MAU by 1989;

and REQUESTS the Director General to submit to Council the Level of Resources for the period 1985-89 accordingly.

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* The 162 MAU figure corresponds to a yearly increase of 5 %

- to study what is the degree of specialisation desirable in industry and the methods of achieving it, as well as the industrial structures capable of meeting European needs, of improving the cost effectiveness of ESA programmes, and of being competitive on the world markets, while striving for a sufficient complementarity between the space firms of the major contributors and the others; and to make proposals to the Council in the near future.

III.2 REAFFIRMS that the objective in the distribution of contracts is to reach an overall return coefficient as near as possible to the ideal value of 1 for all countries and
REQUESTS the Director General to take the necessary measures to achieve a substantial reduction by the end of the next three-year period (1985-1987) in the current imbalances of the geographical distribution of contracts, with the aim of bringing, by the end of 1987, the cumulative return coefficients of all States above 0.95, on the understanding that the appropriate additional measures will be taken from 1988 onwards if this objective is not achieved by the end of 1987.

REQUESTS that correction measures be aimed in the first place at increasing the industrial participation, in particular in the mandatory programmes, of the countries whose overall return coefficient is below the ideal target of 1.

III.3 DECIDES that for the following three-year period (1988-1990) the lower limit for the cumulative return coefficient below which special measures are to be taken to redress the situation and referred to in Article IV, paragraph 6, of the Annex V to the Convention, is fixed at 0.90.

DECIDES that for the next three-year period (1985-1987) the preference clause for the States participating in optional programmes (Article II of Annex V to the Convention) will be waived in favour of the non-participating States whose overall return is below 0.90.

ESA/C-M/LXVII/Res. 2 (Final)

EUROPEAN SPACE AGENCY

COUNCIL

RESOLUTION ON PARTICIPATION IN THE SPACE STATION PROGRAMME

(adopted on 31 January 1985)

The Council, meeting at Ministerial level,

CONSIDERING the offer made by the President of the United States in January 1984 to the friends and allies of the United States of America to participate in the space station programme which he has instructed NASA to carry out within the next decade,

CONSIDERING that the availability of an orbital station represents a decisive phase in the exploration and use of space for peaceful purposes,

RECALLING the implementation of the Spacelab programme and the first Spacelab flight which took place in 1983,

RECALLING that a number of Member States have undertaken, within the framework of the Agency, a Spacelab follow-on development programme and a long term space transportation systems preparatory programme (ESA/C/LIV/Res. 1 (Final)),

HAVING REGARD to Resolution ESA/C/LXIV/Res. 4 (Final) of 28 June 1984 on the execution of a space-station-related Columbus preparatory programme and the corresponding Declaration,

CONSIDERING that participation in the space station programme constitutes one of the elements of the long term plan of the Agency (ESA/C-M/LXVII Res. 1 (Final)),

- to ensure that Europe may have access to and use, on a non-discriminatory basis, all elements of the space station system on terms that are as favourable as those granted to the most-favoured users and on a reciprocal basis;

- to reach a satisfactory agreement on the share of the operation costs of the station;

- to reach a satisfactory agreement on the level and on the conditions for the appropriate transfers of technologies;

- to ensure that supplies and services provided by the United States industry and NASA for European requirements are offset by European supplies and services;

- to ensure maximum legal security and an identical level of the commitments entered into by the European Governments and the United States Government;

- to guarantee the availability of the American transportation and communication facilities required for the programme and the possibility of using the European facilities as they become available for the programme.

III. INVITES the Member States and the Director General to set up suitable machinery under Council authority for drawing up and negotiating the legal instruments with the United States Government and with NASA for the development and utilisation phases of the space station.

IV. AGREES that the ESA Council will review the progress of the negotiations in order to reach a decision with regard to the undertaking of the development, production and utilisation phases of the space station programme before the end of 1986.

Mr. NELSON. Thank you, Professor.

You have addressed the issues very well that we asked you to. And I would like to talk with you about some of these items. First of all, let's talk about the healthy economic competition between our respective countries. Tell me how do you think that NASA's phase 3 pricing for the shuttle might impact the European space community?

Mr. LÜST. Mr. Chairman, the answer for me is rather difficult at this moment, since so far we are not really informed how this pricing policy for phase 3 would look like. Therefore, for us it's difficult to comment at this stage.

My hope would be that this would allow fair competition, but also as I stated, Europe wants to remain the user of the shuttle for quite a number of space projects.

Mr. NELSON. All right. Is there unanimity among the ESA members on this shuttle pricing issue?

Mr. LÜST. Oh, yes, there was absolute unanimity in the ministerial conference in Rome and also in the discussions which I had with the member states on this.

Mr. NELSON. You said just about 5 minutes ago, somewhere around page 12 or 13, your concern with the U.S. Govenment subsidy of the launches for commercial payloads, you were speaking of that subsidy.

Mr. LÜST. Yes.

Mr. NELSON. You were concerned with it. Well, does ESA subsidize their end?

Mr. LÜST. No. The situation is such that Arianespace is a fully independent commercial enterprise. ESA has developed the Ariane 1, 2, and 3 vehicles, and is developing Ariane 4 and will develop Ariane 5. But after the development the launcher is handed over to Arianespace and Arianespace is fully responsible for all later operations and has to recover all the costs.

Mr. NELSON. Now, Professor, you're saying, if I can understand, that there is no governmental subsidy of the Ariane?

Mr. LÜST. No, there is no governmental subsidy for Ariane in the operational phase.

Mr. NELSON. Well, Professor, you and I are not communicating then. Where is the governmental subsidy for the Ariane as a launch vehicle and its operations?

Mr. LÜST. There is no subsidy for Arianespace. Arianespace has to recover all costs which are occurring for building, manufacturing the launch vehicle and has to recover all costs for the launch operation and all for the marketing.

Mr. NELSON. Are you speaking of marginal costs, those costs that we would define as the costs that are generated from consumables, such as the fuel, the manpower associated with the launch and so forth? Are you talking about costs beyond that or are you talking about the marginal costs?

Mr. LÜST. I am talking about all costs for manufacturing the hardware of the Ariane, and I am speaking about all costs for the launch operations, for everything.

Mr. NELSON. Are you including the cost of depreciation of the investment in the Ariane vehicles as well?

Mr. LÜST. No. As I said, the development costs have been paid, and are practically written off.

I should add, if there are new investments necessary for keeping Ariane 1 or keeping Ariane 2 and 3 operational, these costs have to be borne by Arianespace.

Mr. NELSON. The operational costs?

Mr. LÜST. Also if there are new investments necessary.

Mr. NELSON. How about the R&D costs, research and development costs, of Ariane?

Mr. LÜST. Programs are completed as far as the Agency is concerned. For the Ariane 1 to 3, further R&D will have to be paid by Arianespace.

Mr. NELSON. By Arianespace?

Mr. LÜST. Yes.

Mr. NELSON. But that's not figured into your costs that you say that you are recovering?

Mr. LÜST. The Agency is not recovering these costs. Since we are not paying, Arianespace is. We have no item in our budget for further R&D for Ariane 1, 2, 3. We have only the possibility for development costs for Ariane 4 and later for the HM60 and for Ariane 5, since these are running programs.

Mr. NELSON. All right. Now let me talk about that. Repeat for me, please, about the R&D costs for the Ariane 4. How do you figure that into your pricing?

Mr. LÜST. Since Ariane 4 is not yet an operational vehicle, the development costs are paid by the member states of ESA as for any other Agency research and development program. But as soon as Ariane 4 is ready for operation, it will be handed over to the Arianespace, and then it's up to Arianespace to recover the manufacturing costs, launching costs, and so on.

Mr. NELSON. The manufacturing costs and the launching costs, but not the research and development costs?

Mr. LÜST. Not the original R&D costs.

Mr. NELSON. So that's separate and apart from your pricing policy for Ariane?

Mr. LÜST. Right, except that it is Arianespace pricing policy.

Mr. NELSON. OK. Does Arianespace charge exactly the same price for payload to an ESA member as it would to an American communication satellite?

Mr. LÜST. No. Since Arianespace is a commercial enterprise, they try to get the best price that they can get. But since Arianespace is not controlled by ESA, it determines it's prices. I am not the best man to give you an answer to this.

Mr. NELSON. So you don't know if there's a different charge for different payloads?

Mr. LÜST. As far as I know, there is a different charge.

Mr. NELSON. All right. Then I misunderstood you when you said, "But that is a decision by Arianespace"——

Mr. LÜST. Yes.

Mr. NELSON [continuing]. "Not by ESA."

Mr. LÜST. No.

Mr. NELSON. As far as you know, there is a different charge by Arianespace.

Mr. LÜST. Yes, there is a different pricing.

Mr. NELSON. Although you are not speaking for Arianespace, I understand.

Mr. LÜST. But I should add, sir, it might be even different prices for different customers.

Mr. NELSON. Why do you think that would be?

Mr. LÜST. I don't know. But I mean as a commercial enterprise, Arianespace has its own policies for which I could not answer.

Mr. NELSON. OK. Well, we'll explore that as we have further talks with Arianespace.

All right. Let me ask you this. Since you say that you think that the U.S. Government heavily subsidizes the shuttle pricing policy, tell me what you think that the shuttle price ought to be for this phase 3, which is the year 1989-1990-1991?

Mr. LÜST. Would it not be one possibility that also the shuttle would have a full cost recovery as far as production and launch costs are concerned?

Mr. NELSON. Give me your opinion as to whether or not you think that that ought to be included?

Mr. LÜST. My own opinion would be that I don't know really what this would mean for the price, therefore, I am careful in my answer, but for me this would look to be the most logical way to approach this question.

Mr. NELSON. Do you have a dollar figure in mind that you think it ought to be charged?

Mr. LÜST. No, I could not give you any dollar figure. But as I said, ESA is also interested in the launch cost of the shuttle, since we will use the shuttle.

Mr. NELSON. Sure. Well, take, for example, up through in the time period 1986, 1987, and 1988, the charge for the equivalent of a full shuttle bay, cargo bay, is $71 million in I think 1982 dollars. All right. Do you think that the charge for the ensuing 3 years after that for 1989, 1990, and 1991, do you have an opinion, should it be higher, should it be lower, should it be the same? Do you have an opinion on that?

Mr. LÜST. No, Mr. Chairman, I have at present no opinion on this.

Mr. NELSON. OK. Let me ask you again about the charges on Arianespace. I know you're here not speaking for them, you're here speaking as the head of ESA. But you have made these commentaries here. You said, for example, in your statement on page 12 that the Arianespace ELV Program had had tremendous success because of relative simplicity in the design and the capacity to launch dual payloads. You said favorable economic conditions were a contributing factor, and you also said reasonable pricing policy.

So since you have stated that as the head of ESA, tell me, in your opinion, does Arianespace, does it charge—you said it charges some different prices for different payloads—is it higher or lower for member states?

Mr. LÜST. For member states, as far as I am informed, it's slightly higher that the member states have to pay.

Mr. NELSON. In other words, the member states of ESA, who also participate with Arianespace, that the charge to them is higher as a launch fee?

Mr. Lüst. Slightly higher as a launch fee.[1]

Mr. Nelson. All right. Let me share with you my considerable happiness over the state of your negotiations over the space station. It's my understanding you're meeting with Mr. Beggs. You've met with him before in Europe. You made reference to the ministerial level contacts. You're talking about an investment of, in dollars, close to $2 billion over and above what the United States invests. And Japan has indicated a considerable interest. So has Canada. And that is truly international participation. And I think that is just really admirable. And I encourage you, and we're going to look forward to that kind of continuation of negotiations.

How would you characterize the progress that is now being made between NASA and ESA on the space station phase B agreement?

Mr. Lüst. They have not really declared from both sides that we have finished the discussion about this, but my impression is that maybe in a very short while all outstanding questions will be solved, and I am confident that very soon the MAU will be ready for signature by both sides.

Mr. Nelson. All right. Can you tell me how would you describe the participation in the U.S. Space Station Program contributes to Europe's longer-term goal of achieving autonomy in manned space station activities? How does your participation in the space station help you toward that long-term goal?

Mr. Lüst. I think this has two aspects. The first aspect is that certainly it is my personal firm conviction Europe should always participate, cooperate with the United States on space programs. And the space station is a very important element of this, and I am convinced that also when we have finished the space station, there are new possibilities for such cooperation.

But the second aspect is that since the space station might have also—this is also the hope, I believe, of every government—some aspects of commercialization. One has to see that also Europe has the possibility for a fair competition if there is commercialization. And for this reason, Europe would like to be, if necessary, to be in the position to be autonomous also as far as man-rated space stations are concerned.

Mr. Nelson. Mr. Brown.

Mr. Brown. Just to amplify slightly on the line that the chairman was following with regard to the pricing policy on the launch vehicle. Your statement said that major cost elements on the shuttle were not included in the pricing. Did you have specific cost elements in mind that you might care to specify?

Mr. Lüst. Now, there I have the difficulty that there are indications for this, but we have asked about information so far which we have not obtained. So I think the best way for clarifying this point, if we would get the information—"we" means the European side—for really having an open discussion on this.

Mr. Brown. Well, I think that is proper personally. I think that you should provide the United States with the elements and the costs of Ariane, and we should provide you with the cost elements in the shuttle, and we should reach agreement that what is fair for one is fair for the other. Would you concur in that approach to the problem?

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[1] See App. 3, letter to Congressman Nelson from Reimar Lüst, 30 May 1985.

Mr. Lüst. Oh, completely. But we have given all the information on our pricing policy of the Ariane, and we were hoping that now in the process of consultation we would also get informed on the pricing policy on the other side.

Mr. Brown. Well, I think that's a fair approach. I don't think our country has yet reached a definitive policy with regard to what we should do. And I know it's a matter of considerable discussion within this committee as to what the proper approach should be.

Let me just briefly discuss one other area. Clearly, ESA is very much interested in the development of your remote sensing capabilities and have a number of projects in that area. I point to the development of communication satellites which, over the last 20-odd years have become a major industry and which are subjected to some degree to a rule of international law through the work conferences and so on.

The point of my questions is, do you think we may be moving toward the situation in which we need an international framework within which to discuss the low-orbiting satellites such as the meteorological satellites and the earth-observing satellites where there would be considerable economies from the joint or shared use under a common international agreement from these platforms?

Mr. Lüst. I personally would most welcome it, and I am sure that our agency would welcome it if such an agreement could be reached and even better coordination than we have could be achieved.

As far as meteorology is concerned, there is very good cooperation and exchange of data and NASA is helping Europe for certain regional parts. But this does not mean that there is considerable room for improvement for getting an agreement on this.

May I add that just between NASA and ESA, we have a common working group just for the field of remote sensing in order to coordinate the different tasks of both sides.

Mr. Brown. Do you have any views with regard to the commercial potential of the Earth-observation satellite? Obviously, the French are moving ahead with SPOT, and you have indicated a number of other nations are moving ahead with their own program. As I visualize what could happen here, we could have a number of national competing commercial operations with a substantial overlap and a substantial economic penalty being paid as a result of this.

Has ESA tried to project into the future 10 years or 15 years with regard to what conceivably could happen in this area?

Mr. Lüst. The member states and governments have asked ESA to develop and make proposals for a policy, but I must confess that we have not gone too far in this. And since I am rather new in the field, I must also confess that I regard this as a rather difficult thing; namely, to be convinced that full commercialization, full cost recovery, would be possible in this field. I think this needs still much thought and studies to see in which ways this can be best approached.

But I share your view that we must also find solutions to wide applications and overlaps, as you have indicated.

Mr. BROWN. Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Brown.

Mr. Torricelli.

Mr. TORRICELLI. Thank you, Mr. Chairman.

Professor, you pointed out that NASA, in pricing the shuttle, does not include the cost of all the research or even currently of all construction; therefore, that price in the marketplace is somewhat of a fiction. Is that your view?

Mr. LÜST. We are not talking about the R&D costs for the shuttle, but our concern is more really the actual production costs for the shuttle and for the operational costs.

Mr. TORRICELLI. If we are going to introduce the analogy of the marketplace, one would have to include all of these elements of research and design. We cannot take marketplace scenarios and ideas and take them in part.

Mr. LÜST. I agree, but research costs are always difficult in which they can be included. Therefore, I think this must be a point where one must first have an exchange of ideas and see really both sides before one could come to a conclusion.

Mr. TORRICELLI. Yes. I am certainly in favor of an exchange of ideas, and I think that the discussions that are going on are very useful. But there has been a tendency in our Congress to try to invoke the concepts of the marketplace and to have this become a free and open competition among technologies and between our countries.

But they really have no place. Two companies cannot price their products and just take out major cost elements of marketing or research or construction and say, "Well, this is a marketplace price." It all has to be included.

Now, those who would like to price the shuttle are doing that on our side of the ocean. They're saying, "Well, let's take the cost of construction of it and let's take some of the research costs." But in fact, if we were to price the full costs of what it takes the United States to put the shuttle into orbit, one would have to go back many, many years with different parts of our space program, take all of those research costs, because they all contributed to the shuttle, and put those into pricing it.

Just as an automobile company would have to take the cost of what it took to have the breakthrough years ago in certain elements and to put that into a current car, my point would be the same with you. Our prices are a fiction, I will admit that. So, sir, are yours. They are administratively set because you decided to take some of the costs of your research or some of the costs of your development or your construction, and not all.

Mr. LÜST. In this respect, Mr. Chairman, all these kinds of prices are fictions. But I believe that the prices of the Ariane, at least in this way, can be clearly defined at present, we say the costs, the real cost from end of development on, must be recovered while so far this has not been stated for the shuttle.

Mr. TORRICELLI. Yes. I understand we're reaching our prices differently by different accounting and different policies. But my point—and I don't want to belabor it—is simply neither of them reflect marketplace conditions, neither can adopt an analogy of business practices. They are both administrative prices. You have decided to set yours—and I give you full credit for it—by taking the current costs of that construction and placing it in orbit. Perhaps we have not. But these are not business practices, by any stretch of the imagination. And I don't want to continue the point, but I think it was worth making.

Mr. LÜST. No, I can certainly agree with the chairman, but in all fairness then I should state that not we from the European side have started the question of pricing.

Mr. TORRICELLI. Professor, let me ask you to characterize your impressions of the possible use of the space station with our joint cooperations for American and European military purposes. What are your understandings on possible limitations on the availability?

Mr. LÜST. Mr. Chairman, as you know, according to the convention of the European Space Agency, we are only involved in space matters for peaceful use. So therefore, certainly, any aspect which would have military direct applications on the space station would not be—could not be treated and could not be handled by ESA.

Mr. TORRICELLI. Well, you have stated a need for full access on the station, access to the technology and access to different aspects to what is occurring. How then do you interpret possible need in the future if the United States were to decide that a military experiment needed to be taken place or observations or military technology were going to be placed on it, if you see your participation not in part of the station but in the station as a whole?

Mr. LÜST. I would think certainly this matter has to be further discussed so that one really has a better understanding, also we on the European side. Second, as there were no difficulties for the shuttle, since the shuttle is also used for civil use and for military use but this did not exclude participation of the European side for building spacelab, I would think also agreement can be reached as far as the space station is concerned.

Mr. TORRICELLI. I have no doubts one can be reached, but the fact of the matter is that we are not operating under any such agreement. This has yet to be achieved.

Mr. LÜST. Indeed. I mean we have only reached particular agreement for the phase B, and as agreement for the phase C and D still have to be reached, and probably it will be somewhat more difficult to reach this agreement than just for the phase B.

Mr. TORRICELLI. I wondered finally, Professor, some of us are concerned that our concepts of the future for European and American cooperation in space may be slightly different. My view of the President's offer to the Europeans on the space station was a beginning step on a marriage of space cooperation, that there was no need for nations to pursue their ambitions individually, the costs were so great and the advantages so enormous for all humanity, that this is something that should be done together.

Based on your comments this morning, it appears to me that we are headed for less of a marriage than for a brief affair, that we will cooperate on this endeavor, the Europeans will gain what is available, take that technology which is available, and then we will go our separate ways.

That is a different concept to me than what I thought the President had in mind. I wondered if you could characterize for me in that light what are the long-term advantages for the United States of having cooperation on the station if in fact the European ambition is to have your own independent program in the future.

Mr. Lüst. Well, as I stated several times in my statement and also as I have given answers to questions, this would be a wrong interpretation of the aims in Europe, since there should be and is a clear political will not to cooperate just on the space station but to have long-ranging cooperation.

But on the other side, I think it's a necessity for Europe to have also its own capabilities and its own means in the areas where it's necessary. I believe this has been demonstrated by the Ariane. And finally, I should say, knowing how cooperation works in Europe, you see there are certain parts of projects which are so large where one should cooperate, and the space station is just the beginning of this.

Mr. Torricelli. So you see this as a relationship where occasionally because of the scope of projects we might come together and then on occasion separate but not a permanent relationship. It will be one of convenience and need on occasion with different projects?

Mr. Lüst. No, not on occasion, but I see this as it has been in the past, as a firm standing cooperation, but for certain satellite projects it would make no sense that this would be cooperative projects. Others would be less expensive for each side if you do them in cooperation than if you do them alone. So it's really the threshold which counts, but knowing that each side is really an equal partner and can participate in an equal partnership.

Mr. Torricelli. Well, let me just give you briefly my reaction to that. We've talked about the need to recover costs and the research and development costs of these projects. One could not begin to argue that full access to the technology of the space station, its development, the years of work and the breakthroughs in science that make it possible, approaches $2 billion. The full cost of the space station is not the $8 billion it's costing the United States for our part to put it into orbit. The cost is tens of billions of dollars, all the way back to the Mercury Program and developing the technology that made that possible.

I still think that's acceptable and I think it makes sense for the United States if, for our $8 billion and for your $2 billion and for the Japanese $1 billion, we are putting the past behind us and agreeing now to go together into the future.

But if, on the other hand, what Europe is buying into is not a permanent relationship but access to tens of billions of dollars worth of American technology for a $2 billion price tag, frankly in my mind that's a whole other matter and gives me some pause.

Would you like to react to that?

Mr. Lüst. The cost of $2 billion as the European contribution is not a small contribution so thereforein all fairness I think this is a good basis for cooperation, not just for this project. I know that the problem of technology transfer is a very sensitive one, but I should point out that in the public of Europe it is as sensitive as it is here. And I think the future relation—a strong relation which I wish—should really be seen also under this problem.

Mr. Torricelli. Thank you, Professor.

Mr. Nelson. Thank you.

The committee will recess. We have to go vote, Professor. We will go over and vote and come right back and continue with our questioning. So the committee will stand in recess.

[Recess taken.]

Mr. VOLKMER [presiding]. Professor Lüst, I was reviewing your statement. I wasn't here for your oral presentation. But I reviewed it and also the appendix or addenda attached thereto. And I would like to address some questions that I find in regard to the Columbus project.

First, what are some of the operational objectives of this project?

Mr. LÜST. The operational objectives are very much in line with the objectives also which are developed here. So we foresee a station where especially the microgravity aspect is a very important one, as it has been earlier in spacelab, but on the space station you will have much better conditions. You have much longer-duration experiments, until you finally have a possibility of even developing commercial products under microgravity.

Also, bioscience, there are important aspects that experiments in which the space station will contribute. But also in what I would call the more traditional space science which had so far been participated in space will benefit. I am convinced that one can use it directly as an observing station but also—and I think this is for the astronomers is probably more important—that you have a base for servicing, refurbishing free-flying astronomical observatories.

As we are thinking on the space telescope, which should have a duration for 15 to 20 years, I think it would be unrealistic if it should not be serviced during this time. Servicing has an even more important aspect for infrared astronomy where you need constant cooling and replacement of the cooling elements.

But also, if one is thinking on earth observation, there are completely new possibilities for the whole field of earth observation, when one thinks of the space station and of the platforms linked to the space station in polar orbits and in low-inclination orbits.

Mr. VOLKMER. Fine. But it sounds like a very demanding type of project. I notice in your statement that you state you will be running space station phase B studies, 1985 and 1986, parallel in close cooperation. NASA's phase B activities, we are currently planning studies for the development of a pressurized module for orbiting and polar orbit platforms, resource module servicing vehicle.

Now, are we talking about the Columbus in those Phase B studies? Is that the same as the Columbus project?

Mr. LÜST. Yes. Columbus is synonymous for the European part of the space station.

Mr. VOLKMER. All right. I find also in the appendix that we have something—if I can find it real fast—a figure in units. I think it was 2,600 million units?

Mr. LÜST. Yes.

Mr. VOLKMER. 2,600?

Mr. LÜST. 2,600 million European Accounting Units.

Mr. VOLKMER. Are those annual amounts, those units?

Mr. LÜST. No; Accounting units are this fancy European currency.

Mr. VOLKMER. I understand that, but I can't relate that to dollars very well.

Mr. LÜST. Yes.

Mr. VOLKMER. Or francs or anything else. Perhaps you can.

Mr. LÜST. The 2.6 billion accounting units corresponds to $2.1 billion.

Mr. VOLKMER. Fine. Now, is that a total cost until 1995?

Mr. LÜST. This should be the total cost, including for a 3-year period the operational cost and the initial utilization.

Mr. VOLKMER. And then in the next page on the agenda it provides for microgravity, and in there you have a funding for 30 million accounting units in 1985, 80 million accounting units per year until the year 1988 and 1992, and then the funding for the following year is being included in the Columbus Program.

Until that time, the microgravity research and development is going to be separate from the Columbus Program?

Mr. LÜST. Yes; It is separate. And one way this will make use of Spacelab, therefore of the shuttle directly. And the other way it will use the so-called EURECA, which I described in my statement. And it should be really regarded as a preparation also for the Columbus Program, for the Space Station Program.

Mr. VOLKMER. Now, as I am envisioning this, too, and reviewing the whole document—you please correct me if I am wrong—do you envision that by 1995 that Ariane 5 will be capable or have the capability of placing platforms in space that will be similar to the Columbus platforms or modules?

Mr. LÜST. The capability of the Ariane 5, as foreseen now for the year 1995, will be that the Ariane 5 can bring into geostationary orbit payloads of 4.55 meters diameter, and a weight of 5 to 8 tons. But in 1995, certainly, Ariane will not be in the position to bring a man into orbit. If the project Hermes will proceed as a European project, as I indicated, it probably would not be before 1998 or even later.

Mr. VOLKMER. But it would be capable of placing and servicing modules or material modules into orbit with whatever you have—we call it the Columbus—with the space station?

Mr. LÜST. I must confess that it——

Mr. VOLKMER. Or is that a vision?

Mr. LÜST. This is at the moment probably more vision than foreseen so far. The planning, so far is that the parts for the space station would be brought up by the shuttle at that time, and the Ariane 5 for that time would be a launcher for large satellites in low earth orbit as well as in geostationery orbits.

Mr. VOLKMER. Yes, but what we recognize is the fact that the space station is not something that we're just going to take something up to in 1992, or 1993, or 1994 and then that's all that's going to happen to it and then by 1996, 1997, or 1995 we're not going to have anything more to do with it. We're going continuously to provide not only personnel but material, et cetera, to the space station.

What I am getting at is do you envision that Ariane 5 would be part of the transportation mode to the space station in that time period?

Mr. LÜST. So far, this question really has not been deeply looked into from the European side, since certainly this question would be then connected with the men-rated Ariane 5, and its possibility of docking to the space station.

Mr. VOLKMER. Do you envision—and what I was just wondering about as I read the total and far-looking paper that you have here today—also is, is ESA looking at the possibility that sometime in the future you would have your own—you could call it a space station, you can call it modules put together, whatever it is—by the year 2000?

Mr. LÜST. This cannot be excluded. This depends, of course, first of all, on the success of the space station, but also it depends which way one is using the space station. So therefore, for the moment we have the means for and the wish to have this as a cooperative project, but if finally for one reason or another a European independent station would be desirable, certainly this should be and could not be excluded.

Mr. VOLKMER. To get back to the Columbus Program very briefly, do you foresee any difficulties in that in the phase B studies run concurrently with NASA's as far as any future continued cooperation on the space station with NASA?

Mr. LÜST. No, to the contrary. All the experience in the past has shown that the cooperation is so well established that I would not expect difficulties for phase B nor would I expect difficulties for the phase C and D.

Mr. VOLKMER. Thank you very much.

Mr. LÜST. The only difference for phase C and D is that we need a different agreement.

Mr. VOLKMER. All right. Thank you very much. I would like now to turn to some scientific questions with regard to your planetary explorations and monitoring satellites, et cetera.

Your remote sensing satellite, ERS-1, to be used for ocean and coastal zone monitoring, scheduled for launch in 1989, would data from this satellite be made available to U.S. agencies and other international organizations?

Mr. LÜST. Yes.

Mr. VOLKMER. Thank you very much. I appreciate that. Then with respect to remote sensing projects in a broader context, what is ESA's general position regarding the distribution of raw data from civil remote sensing satellites on a nondiscriminatory basis to all interested parties?

Mr. LÜST. We want to follow the same policy as the United States has followed in this area.

Mr. VOLKMER. Thank you very much. To your knowledge, has the International Committee on Earth Observation Satellites taken a position on this access issue?

Mr. LÜST. Not yet, but I think they will take this position which I have just outlined.

Mr. VOLKMER. Same position as we all have. Fine.

Now, in addition to joint programs in solar terrestrial physics, what other areas of space science do you see the greatest opportunities for U.S.-European cooperative efforts?

Mr. LÜST. I would hope very much that we would have interesting projects in the planetary field. This is a field which really is inviting for cooperation, since projects have such a size that certainly I would think both sides would gain tremendously for full collaboration.

Mr. **Volkmer**. Thank you very much.

That concludes my questions, and I appreciate your being here. I will turn the committee back over to the chairman.

Mr. **Nelson** [presiding]. Thank you very much.

Thank you very much, Mr. Volkmer.

Professor, we appreciate it very much. We wish you well in your visit here in the United States and your conversations with NASA. We welcome you with genuine warm hospitality, and we will look forward to visiting with you in Europe at a later date.

Thank you all for participating.

Mr. **Lüst**. Thank you very much.

Mr. **Nelson**. Have a good day.

I would like to call up Mr. Aldridge, please.

[Pause.]

Well, we are delighted to have the Honorable Edward Aldridge, Jr.—otherwise known as "Pete"——

Mr. **Aldridge**. Thank you, sir.

Mr. **Nelson** [continuing]. Under Secretary of the Department of the Air Force.

We are certainly eager to hear your presentation of the Air Force's views on a number of topics, including the adequacy of the space transportation system to meet the military launch needs, other items such as the projections of DOD launch demand for the shuttle, the current status of the Air Force plans to develop and utilize a shuttle equivalent ELV, and other such things as plans for the refurbishment and use of the Titan II ICBM's as space launch vehicles. And that just starts the list.

I want you to know it has been personally a delight to work with you as a friend and now, as chairman, to work with you. And I look forward to that continued cooperation. So if you would, share with us your comments.

STATEMENT OF HON. EDWARD C. ALDRIDGE, JR., UNDER SECRETARY, DEPARTMENT OF THE AIR FORCE

Mr. **Aldridge**. Yes, Mr. Chairman. It's a pleasure to be before you, as the new chairman of this subcommittee, for the first time. I am also pleased to be able to respond to the committee's request for our current views on the DOD space programs which are NASA-related.

I have a formal prepared text which I will submit for the record. For the hearing this morning, I will provide the committee a brief oral summary of the prepared text and, of course, will be happy to answer any questions the committee may have.

Specifically, I would like to discuss the status of the January STS mission and its inertial upper stage, the status of the Vandenberg launch and landing site, and some thoughts concerning the DOD space launch strategy.

I am most pleased to announce our complete satisfaction with the performance of the shuttle Discovery and the inertial upper stage on the mission 51C, the first dedicated DOD launch. While the mission still remains classified, I can say that the IUS worked well. As you know, on STS number 6 in April of 1983 an IUS had a serious malfunction while launching a tracking and data relay satellite for NASA. The performance on 51C was well within the specifications of that mission. Thus, we're once again on a successful track.

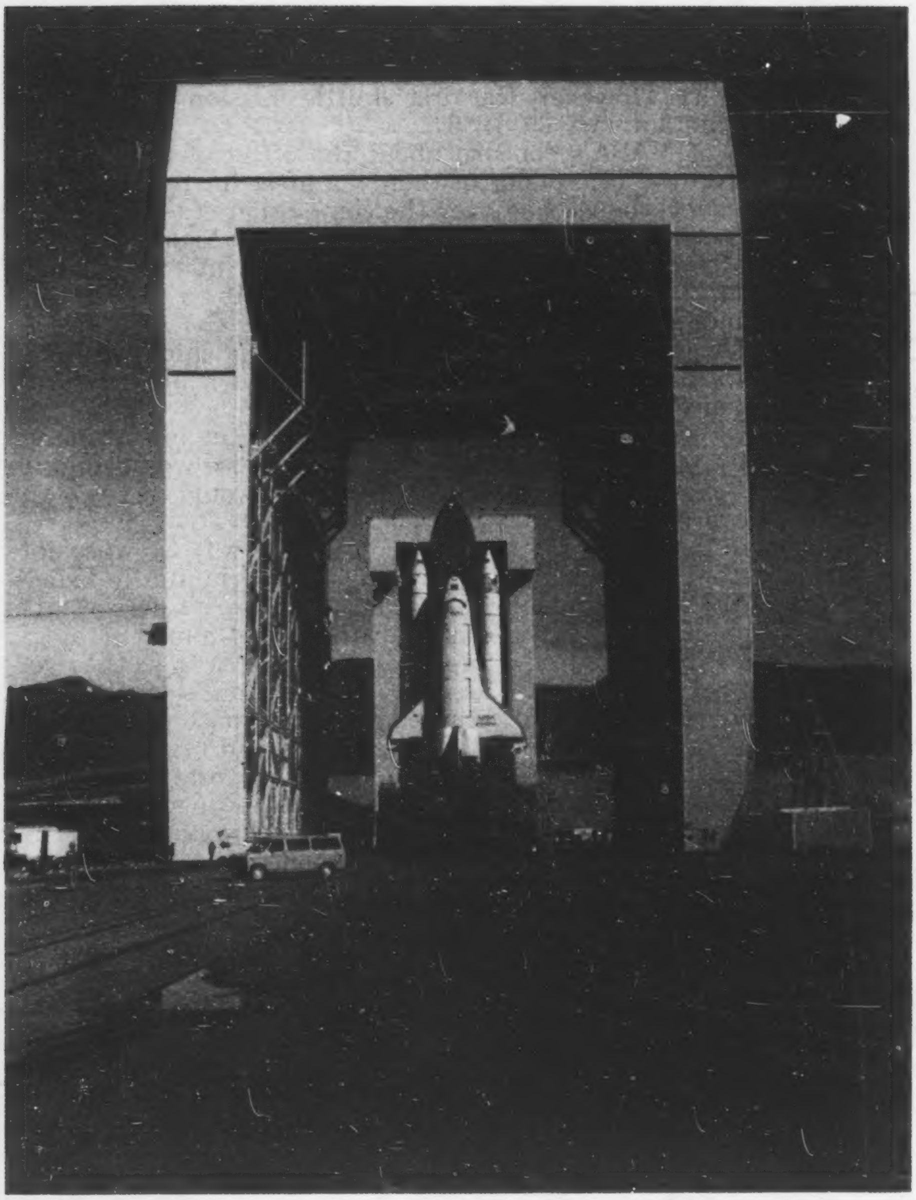
In spite of the unfortunate publicity of this flight, there was an unprecedented level of cooperation between NASA and the Air Force in carrying out this mission to its outstanding success. There is no doubt that this spirit of cooperation will carry forward to future DOD flights.

The Vandenberg launch and landing site is another outstanding example of DOD and NASA partnership and cooperation on the shuttle. With no major problems noted, everything is going better than expected and we are on schedule. The Air Force has almost completed the construction and testing. To date we have successfully run the nonflight space shuttle *Enterprise* through its paces in the facility, culminating with stacking it and external tank and inert solid rockets on the launch pad.

All the large mobile structures have been moved and mated for the purpose of stacking the *Enterprise.* And I have brought a recent picture of the final results to you, Mr. Chairman, to show you exactly where we stand on that. We will provide additional copies to the remaining committee members. We just had a few copies there.

Mr. NELSON. That will be entered as part of the record.

[Material referred to follows:]



Mr. **Aldridge**. Yes, sir.

The external tank for the first Vandenberg flight is already on the base in storage. We're on track to be able to launch—our support launch is after October 15, 1985. That is the day of our initial launch capability. However, the first shuttle mission is not scheduled earlier than January 29, 1986.

As a result of NASA's concern about the effect of their orbiter tile problems on the remainder of their manifest for this year, and as a result of concerns we had over the completion of testing of our payload for the first Vandenberg flight, Mr. Jesse Moore of NASA and I mutually agreed that it was in the best interests of both agencies to slip the first Vandenberg launch until no earlier than the end of January 1986.

Thus, NASA gets two more flights off this year which we would have lost if we had held to the October date, and it also gives me higher confidence that our payload will be ready.

However, we will continue to press forward for the initial launch capability date of October 15, 1985. To do otherwise would require us to extend several fixed-price contracts, which would increase the cost to the government.

I would like to express my appreciation for the way we were able to work together with NASA in agreeing to this mutually beneficial delay of the first Vandenberg launch.

Next, I would like to turn to our future space launch strategy. The requirement for assured access to space derives from the ever-increasing importance of space assets to our national security.

The defense requirement for assured access to space under conditions of peace, crisis, and conflict is a validated and urgent requirement which has been stated unambiguously in several administration policy documents. The need for assured access to space is fully consistent with the President's July 1982 national space policy.

The requirement for a complementary expendable launch vehicle is the product of many space architecture and launch vehicle studies, as well as the DOD net assessment of the total space operation and space launch posture. The CELV requirement was restated by the President in his 1984 national space strategy and by the Secretary of Defense in a February 1984 memorandum, "Defense Launch Strategy."

This need was further endorsed by the National Research Council report chartered by the Congress in 1984 and most recently by the President's "National Security Launch Strategy," dated February 25, 1985.

As you know, this has been a highly emotional and controversial issue over the past year or so. And let me say it's also an often misunderstood issue. The misunderstanding has been related to a misconception that the complementary ELV was only deployed by the Department of Defense to abandon the shuttle. Nothing could be further from the truth.

Over the past several weeks Jim Beggs and I have been working to alleviate the concerns of both NASA and the Department of Defense with regard to the CELV, the shuttle, and future launch vehicles, and have come to major agreement, as reflected in the President's "National Security Launch Strategy." And let me summarize that agreement.

First, we will work together to ensure the shuttle is a viable operational system heading toward 24 flights per year.

Second, NASA will agree with the need for a complementary ELV to the shuttle, with the Air Force buying 10 vehicles to be launched at a rate of 2 per year in 1988 through 1992. The type of ELV is to be chosen by the Air Force through a competitive process. We have now chosen the Titan derivative, the Titan 34D7, as the winner of this competitive procurement.

Third, DOD will commit to at least one-third of the available shuttle flights over the next 10 years. Let me add that this is independent of and in addition to the number of expendable launch vehicles to be flown during that period.

Mr. NELSON. Let me interrupt you right there. You are basically figuring on the 24-flight-a-year configuration. So that you're looking on the average over that 10-year period——

Mr. ALDRIDGE. Yes, sir.

Mr. NELSON [continuing]. Of an average of eight flights per year.

Mr. ALDRIDGE. Yes, sir. At least eight flights per year.

Mr. NELSON. That you're committing to.

Mr. ALDRIDGE. Yes, sir.

Mr. NELSON. And does that commitment start in 1986, 1985, 1989? When does the 10-year commitment start?

Mr. ALDRIDGE. We tried to start it in, I believe it is, 1985–86. I don't remember exactly because we have to look at what the rate of buildup is. But we tried to take a period long enough that we could absorb the peaks and valleys over that commitment. But we are committed to the total available flights, one-third of them. And I believe it starts probably in 1986, early 1986, essentially now.

Mr. NELSON. And I want to underscore this as a result of our private conversations, that you and I had talked about that it had been misunderstood among some publications that had reported that, as you had said here earlier, that the Air Force was trying to abandon the shuttle, and that some comments had come out to the effect that the Air Force didn't have any reliance in the shuttle.

Would you state for the record loud and clear so that the world will know, what is your feeling?

Mr. ALDRIDGE. Sir, I will state it several times if you want me to state it. It is essential to the national security of this country that the shuttle be reliable, effective, and operational. We are still commiting one-third of the total flights, which is essentially eight flights per year on the shuttle. It is absolutely a requirement that it be reliable and operational. And I believe that NASA is going to provide that capability for us.

Mr. NELSON. Please continue.

Mr. ALDRIDGE. The fourth item of agreement was that we would develop a new pricing policy for the DOD use of the shuttle flights that will give us positive incentive for DOD flights on the shuttle. NASA will provide input on that by the 15th of April, a proposal on how to proceed with that particular item.

Fifth, we will work together to define a second-generation space transportation system, using manned and unmanned systems to meet all the user needs.

And finally, any changes to that agreement must be approved by the President.

Mr. Chairman, we are very happy with this particular agreement, and encouraged, and believe that it sets us on a new course for our future launch capabilities for this Nation.

The Air Force is taking another step in launch vehicle procurement. As a part of his strategic modernization program in 1981, the President announced his decision to deactivate the Titan II intercontinental ballistic missiles. As I reported to this committee last year, the Air Force initiated a study to determine if there were a cost-effective use for these residual national assets. We have some defense programs which require small launch-on-demand satellites to be infrequently placed in unique low-altitude polar orbits.

The study found that the Titan II could meet the launch needs of these small defense payloads, such as the Defense Meteorological Satellite Program [DMSP].

Based upon our successful experience with Atlas ICBM and Thor IRBM conversions to space launch vehicles, we're proposing to begin conversion of the Titan II's currently being deactivated from three bases in the United States. We plan to convert these 25-year-old missiles into space launch vehicles for use only for the west coast launches from 1988 through 1995.

The use of the Titan II instead of a shuttle for such programs makes economic and programmatic sense. For instance, the DMSP's unique polar orbit and launch-on-demand schedule would require a dedicated shuttle launch for this one small payload, which would use less than 10 percent of the shuttle's polar launch capability, which does not require manned intervention and which does not lend itself to mixing with other missions.

This would be an extremely inefficient and ineffective use of the shuttle. Using the Titan II frees the orbiters to be used on other more efficient and profitable missions.

The total cost to the taxpayer for a Titan II space booster launch will be about $30 million. Employing Titan II's as launch vehicles responsibly uses the prior national investment in these missiles. Rather than scrap them, we will get a productive use from them, much as we have done with the old Atlas and Thor ballistic missiles.

The cost to accomplish this is $65 million for the initial conversion and approximately $15 million apiece for refurbishment. This DOD initiative is reflected in the fiscal year 1986 President's budget. As a nation we should have the most versatile and capable launch systems anywhere.

I believe that we have that opportunity facing us today. We must create an environment for the launch capacity for each of our space sectors—civil, commercial, and national security—to complement each other rather than compete. We must foster all three capabilities and use each in its most advantageous application if we are to maintain our national space transportation leadership.

This concludes my remarks, Mr. Chairman, and I will be happy to answer any questions that you may have.

[The prepared statement of Mr. Aldridge follows:]

DEPARTMENT OF THE AIR FORCE

PRESENTATION TO THE

HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

SPACE SCIENCE AND APPLICATIONS SUBCOMMITTEE

SUBJECT: DOD SPACE PROGRAMS - NASA RELATED

STATEMENT OF: MR. EDWARD C. ALDRIDGE
UNDER SECRETARY OF THE AIR FORCE

7 MARCH 1985

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE:

IT IS A PLEASURE TO BE ABLE TO SHARE WITH YOU THE MOST CURRENT STATUS OF THE DEPARTMENT OF DEFENSE INVOLVEMENT IN THE SPACE TRANSPORTATION SYSTEM. SINCE I LAST TALKED TO YOU, A NUMBER OF SIGNIFICANT ACTIONS HAVE OCCURRED, AND I WOULD LIKE TO ADDRESS EACH OF THEM. SPECIFICALLY, I WOULD LIKE TO DISCUSS THE SUCCESS OF THE MOST RECENT STS MISSION AND ITS INERTIAL UPPER STAGE, THE CENTAUR UPPER STAGE DEVELOPMENT, AND THE STATUS OF THE VANDENBERG LAUNCH AND LANDING SITE. FINALLY, I WOULD LIKE TO SHARE SOME THOUGHTS WITH YOU CONCERNING SPACE LAUNCH STRATEGY.

I AM MOST PLEASED TO ANNOUNCE OUR COMPLETE SATISFACTION WITH THE PERFORMANCE OF THE SHUTTLE ON MISSION 51-C, THE FIRST DEDICATED DoD FLIGHT. WHILE THE MISSION STILL REMAINS CLASSIFIED, I CAN SAY THAT THE INERTIAL UPPER STAGE WHICH WAS CARRIED ABOARD THE DISCOVERY WORKED WELL. THE EARLIER PROBLEMS, ON STS-6 IN APRIL 1983, IN WHICH THE INERTIAL UPPER STAGE HAD A SERIOUS MALFUNCTION WHILE LAUNCHING A TRACKING AND DATA RELAY SATELLITE FOR NASA, SEEM TO HAVE BEEN SOLVED. THE PERFORMANCE OF THE INERTIAL UPPER STAGE WAS WELL WITHIN SPECIFICATIONS FOR THE MISSION. THUS, WE ARE ONCE AGAIN ON A SUCCESSFUL TRACK, BUILDING ON THE IMPRESSIVE RECORD OF THE SHUTTLE ITSELF. WITH THE AIR FORCE'S PLANNED BUY OF THREE MORE INERTIAL UPPER STAGES IN JULY, THE TOTAL REMAINING IN THE INVENTORY WILL BE 14 VEHICLES.

THE NEXT MAJOR STEP IN UPPER STAGES WILL BE THE CENTAUR. THE AIR FORCE AND NASA ARE JOINTLY DEVELOPING THE SHORT VERSION, CALLED CENTAUR G, FOR LAUNCHING LARGE SATELLITES TO HIGH EARTH ORBIT FROM THE SHUTTLE. THE LARGER VERSION OF THE CENTAUR, CALLED THE CENTAUR G PRIME, IS BEING DEVELOPED BY NASA TO LAUNCH THE EUROPEAN ULYSSES (INTERNATIONAL SOLAR POLAR) SATELLITE AND NASA'S GALILEO (JUPITER ORBITAL PROBE). BOTH THE CENTAUR G AND G PRIME HAVE SUCCESSFULLY PASSED THEIR PRELIMINARY AND CRITICAL DESIGN REVIEWS. THE CENTAUR G PRIME TEST VEHICLE HAS BEEN FABRICATED AND IS PRESENTLY IN STRUCTURAL DYNAMIC TESTS. G PRIME COMPONENT QUALIFICATION TESTS ARE PROCEEDING AT THIS TIME, AND I WILL TELL YOU MORE OF THAT IN A MOMENT. THE FIRST CENTAUR LAUNCHES WILL BE NASA CENTAUR G PRIMES, LAUNCHED SIX DAYS APART, FOR THE PLANETARY MISSIONS IN MAY OF 1986. THE CURRENT PROGRAM COSTS FOR THE DESIGN, DEVELOPMENT, TESTING, EVALUATION (DDT&E) AND PRODUCTION IS ABOUT $ 800 MILLION FOR THE FIRST FOUR VEHICLES. OF THIS, THE DoD SHARE IS APPROXIMATELY $ 150 MILLION FOR THE DDT&E, AND $ 200 MILLION FOR THE PRODUCTION, OR A TOTAL OF $ 350 MILLION.

WE HAVE HAD SOME RECENT CONCERNS ABOUT THE COST PERFORMANCE OF THE PRIME CONTRACTOR, GENERAL DYNAMICS. THE NASA DATA WE HAVE RECEIVED INDICATES A COST OVERRUN IN THE DEVELOPMENT PROGRAM. HOWEVER, WE BELIEVE THAT THE CENTAUR DEVELOPMENT PROGRAM WILL COME IN AT THE PROGRAM CURRENTLY CARRIED IN THE AIR FORCE BUDGET (ABOUT $ 150 MILLION). IT LOOKS LIKE THE TOTAL VEHICLE HARDWARE COSTS FOR THE FIRST FOUR VEHICLES WILL COME

IN ABOUT $ 30 MILLION MORE THAN EXPECTED. BASED ON THE NASA DATA I BELIEVE THAT THIS IS ALSO COVERED IN THE AIR FORCE PROGRAM BUDGET. THE SCHEDULE IS VERY TIGHT, BUT STILL APPEARS ACHIEVABLE FOR NASA'S PLANETARY MISSIONS, WHICH HAVE VERY NARROW LAUNCH WINDOWS FOR THEIR RENDEZVOUS WITH JUPITER. ALTHOUGH THE SCHEDULE IS TIGHT, WE WILL WORK WITH NASA TO HELP INSURE THAT THE PLANETARY LAUNCHES DO MAKE THEIR LAUNCH DATES, AND THAT THE SHORTER VERSION WILL MEET THE FIRST AIR FORCE NEEDS IN FY 87. DUE TO THE GREAT SIMILARITY IN DESIGN OF THE TWO UPPER STAGES, WE EXPECT THAT THE LESSONS LEARNED DURING THE DEVELOPMENT OF THE G PRIME WILL PAY A BONUS IN CONFIDENCE FOR THE CENTAUR G. THE TOTAL BUY OF CENTAURS IS PLANNED TO BE 19 VEHICLES.

OF COURSE, THE CENTAUR IS ONLY ONE EXAMPLE OF THE COOPERATION BETWEEN THE AIR FORCE AND NASA WITHIN THE SPACE TRANSPORTATION SYSTEM DEVELOPMENT. THE AIR FORCE HAS ALMOST COMPLETED THE CONSTRUCTION AND TESTING OF THE VANDENBERG LAUNCH AND LANDING SITE, AND WE FEEL WE ARE ON TRACK TO BE ABLE TO SUPPORT LAUNCHES AFTER 15 OCTOBER, 1985. THAT IS THE DATE OF OUR INITIAL LAUNCH CAPABILITY -- HOWEVER, THE FIRST SHUTTLE MISSION IS NOT SCHEDULED EARLIER THAN 29 JANUARY 1986. I WILL ADDRESS THE SCHEDULE IN MORE DETAIL IN A MOMENT. BUT FIRST, LET ME DISCUSS SOME REPORTS ABOUT OUR PROGRESS AT VANDENBERG WHICH APPEARED IN THE PRESS SINCE THE LAST TIME I TESTIFIED BEFORE YOU. AS A RESULT OF NEWS MEDIA ALLEGATIONS LAST AUGUST THAT THERE WAS A QUALITY CONTROL PROBLEM AT THE VANDENBERG LAUNCH AND LANDING SITE, THE SECRETARY OF THE AIR FORCE, VERNE ORR, ASKED THAT I GO TO VANDENBERG TO INVESTIGATE THE SUBSTANCE OF THESE ALLEGATIONS. IN ADDITION TO MY PERSONAL REVIEW, AN AIR FORCE INSPECTOR GENERAL TEAM WAS DISPATCHED TO CONDUCT AN IN-DEPTH EVALUATION OF THE SITUATION AND FOCUS ON ANY SPECIFIC ITEMS THAT I MIGHT HAVE UNCOVERED. DURING MY REVIEW, I FOUND THAT THERE WERE NO FUNDAMENTAL SAFETY OR QUALITY ASSURANCE PROBLEMS AT VANDENBERG WHICH WOULD PROHIBIT US FROM SUCCESSFULLY AND SAFELY LAUNCHING THE SHUTTLE. THIS EVALUATION WAS CONFIRMED BY THE AIR FORCE INSPECTOR GENERAL IN AN INDEPENDENT REPORT. ALL OF THE MAJOR AND MINOR DISCREPANCIES WHICH WERE NOTED AT THAT TIME HAVE BEEN CORRECTED. TO DATE, WE ARE HALFWAY THROUGH OUR GROUND SYSTEMS TESTS, A POINT IN OUR TESTING PROGRAM WHERE WE HAD EXPECTED ADDITIONAL DISCREPANCIES DUE TO THE MAGNITUDE AND NATURE OF A PROJECT SUCH AS VANDENBERG. HOWEVER, EVERYTHING IS GOING MUCH BETTER THAN EXPECTED, WITH NO MAJOR PROBLEMS NOTED, AND WE ARE STILL ON SCHEDULE. TO DATE, WE HAVE SUCCESSFULLY RUN THE NON-FLIGHT SPACE SHUTTLE ENTERPRISE THROUGH ITS PACES IN THE FACILITIES, CULMINATING WITH STACKING IT, AN EXTERNAL TANK AND INERT SOLID ROCKET BOOSTERS ON THE LAUNCH PAD. THE EXTERNAL TANK FOR THE FIRST VANDENBERG FLIGHT IS ALREADY ON BASE IN STORAGE.

NEXT, LET ME SPEAK SPECIFICALLY ABOUT THE SCHEDULE AT VANDENBERG. RECENTLY, AS A RESULT OF NASA CONCERNS ABOUT THE EFFECT OF ORBITER TILE PROBLEMS ON THE REMAINDER OF THEIR MANIFEST FOR THIS YEAR, AND AS A RESULT OF CONCERNS WE HAD OVER THE COMPLETION OF TESTING OF OUR PAYLOAD

FOR THE FIRST VANDENBERG FLIGHT, MR. JESSE MOORE OF NASA AND I MUTUALLY AGREED THAT IT WAS IN THE BEST INTEREST OF BOTH AGENCIES TO SLIP THE FIRST VANDENBERG LAUNCH UNTIL NO EARLIER THAN THE END OF JANUARY, 1986. THIS ALLOWS NASA TO GET TWO MORE FLIGHTS OFF THIS YEAR, WHICH THEY WOULD HAVE LOST IF WE HELD TO THE 15 OCTOBER DATE, AND IT ALSO GIVES ME HIGHER CONFIDENCE THAT OUR PAYLOAD WILL BE READY. HOWEVER, WE WILL CONTINUE TO PRESS FORWARD FOR THE INITIAL LAUNCH CAPABILITY DATE OF 15 OCTOBER, 1985, SINCE TO DO OTHERWISE WOULD REQUIRE US TO EXTEND SEVERAL FIXED PRICE CONTRACTS. SUCH EXTENSIONS WOULD INCREASE THE COST TO THE GOVERNMENT. I WOULD LIKE TO EXPRESS MY APPRECIATION FOR THE WAY WE WERE ABLE TO WORK TOGETHER WITH NASA IN AGREEING TO THIS MUTUALLY BENEFICIAL DELAY OF THE FIRST VANDENBERG LAUNCH.

NOW, TURNING TO OUR FUTURE SPACE LAUNCH STRATEGY. THE DRIVING REQUIREMENT FOR MORE ASSURED ACCESS TO SPACE DERIVES FROM THE EVER INCREASING IMPORTANCE OF SPACE ASSETS TO OUR NATIONAL SECURITY. THE DEFENSE REQUIREMENT FOR ASSURED ACCESS TO SPACE UNDER CONDITIONS OF PEACE, CRISIS, AND CONFLICT IS A VALIDATED AND URGENT REQUIREMENT WHICH HAS BEEN STATED UNAMBIGUOUSLY IN SEVERAL ADMINISTRATION POLICY DOCUMENTS. THIS NEED FOR ASSURED ACCESS TO SPACE IS FULLY CONSISTENT WITH THE JULY, 1982, NATIONAL SPACE POLICY, IN WHICH THE PRESIDENT DIRECTED THAT "EXPENDABLE LAUNCH VEHICLE OPERATIONS SHALL BE CONTINUED BY THE UNITED STATES GOVERNMENT UNTIL THE CAPABILITIES OF THE SPACE TRANSPORTATION SYSTEM ARE SUFFICIENT TO MEET ITS NEEDS AND OBLIGATIONS. UNIQUE

NATIONAL SECURITY CONSIDERATIONS MAY DICTATE DEVELOPING SPECIAL PURPOSE LAUNCH CAPABILITIES." THE REQUIREMENT FOR A COMPLEMENTARY EXPENDABLE LAUNCH VEHICLE (CELV) IS THE PRODUCT OF MANY SPACE ARCHITECTURE AND LAUNCH VEHICLE STUDIES, AS WELL AS THE DoD NET ASSESSMENT OF THE TOTAL SPACE OPERATION AND SPACE LAUNCH POSTURE. THE CELV REQUIREMENT HAS BEEN STATED BY THE PRESIDENT IN HIS NATIONAL SPACE STRATEGY AND BY THE SECRETARY OF DEFENSE IN A 7 FEBRUARY 1984 MEMO, "DEFENSE LAUNCH STRATEGY." THIS STRATEGY WAS FURTHER ENDORSED BY THE NATIONAL RESEARCH COUNCIL REPORT CHARTERED BY CONGRESS IN 1984.

I AM PLEASED TO ANNOUNCE TO YOU THAT THE LAUNCH VEHICLE WHICH WILL BE USED TO COMPLEMENT THE SHUTTLE WILL BE THE MARTIN MARIETTA TITAN $34D_7$. AFTER AN INTENSIVE INDUSTRY COMPETITION BETWEEN THE MARTIN MARIETTA TITAN AND THE GENERAL DYNAMICS ATLAS, WE CHOSE THE TITAN AS THE INDUSTRY COMPETITOR TO COMPETE WITH THE NASA PROPOSED VEHICLE, THE SRB-X. AFTER EXAMINING THE SRB-X AGAINST THE SAME CRITERIA AS WERE USED IN THE INDUSTRY COMPETITION, THE CHOICE WAS THE TITAN DERIVATIVE. THE TITAN DERIVATIVE WAS THE ONLY VEHICLE WHICH FULLY MET ALL THE CRITERIA WHICH I WILL DISCUSS IN A MOMENT. WE HAVE OBLIGATED THE $ 5 MILLION WHICH CONGRESS ALLOCATED TO US LAST YEAR TO PLACE MARTIN MARIETTA ON CONTRACT TO BEGIN WORK ON THE TITAN $34D_7$, AND HAVE SUBMITTED A REPROGRAMMING ACTION FOR THE ADDITIONAL $ 30 MILLION NEEDED IN 1985 TO HOLD OUR LAUNCH SCHEDULE FOR FY 89.

THE MAJOR CONSIDERATIONS WHICH LED US TO PURSUE A SHUTTLE EQUIVALENT EXPENDABLE LAUNCH VEHICLE AND WHICH FORMED MUCH OF THE BASIS FOR THE CRITERIA USED TO EVALUATE THE PROPOSED ALTERNATIVES, WERE: THE NEED TO COMPLEMENT THE SPACE TRANSPORTATION SYSTEM; THE NEED TO BE ABLE TO HOLD THE LAUNCH DATES OF CRITICAL NATIONAL SECURITY PAYLOADS; THE NEED TO PREVENT FURTHER EROSION OF THE NATION'S INDUSTRIAL AND TECHNOLOGY BASE FOR SPACE LAUNCH; THE ABILITY TO ACCOMMODATE REASONABLY EXPECTED EVOLUTIONARY GROWTH IN PAYLOADS; TO PROVIDE SUPPORT FOR THE PRESIDENT'S POLICY ON COMMERCIALIZATION OF SPACE; AND THE SUITABILITY AND JUSTIFICATION FOR USE OF THE SPACE SHUTTLE IN CRISIS AND CONFLICT.

LET ME EXPAND ON EACH OF THESE FOR A MOMENT.

- COMPLEMENT TO THE STS

  THE REQUIREMENT TO REDUCE NATIONAL DEPENDENCE ON A FEW ORBITERS FOR OUR SOLE ACCESS TO SPACE PROMPTED CONSIDERATION OF OTHER MEANS TO GET OUR SATELLITES IN ORBIT --NOT TO COMPETE WITH THE STS-- BUT TO COMPLEMENT IT. THOUGHTS OF THE LOSS OF AN ORBITER, OR OF EVENTS LEADING TO A GROUNDING OF THE ORBITER FLEET FOR AS LITTLE AS SIX MONTHS, ARE UNPLEASANT, BUT THINKING OF THE CONSEQUENCES OF SUCH THINGS IS PART OF THE PLANNING JOB THE MILITARY MUST DO FOR OUR NATIONAL SECURITY. IF THE ORBITER FLEET WERE TO BE GROUNDED FOR JUST SIX MONTHS IN THE EARLY 1990s, IT WOULD TAKE THE NATION TWO YEARS AT A NEARLY IMPOSSIBLE SURGE RATE OF THIRTY FLIGHTS PER YEAR

TO CATCH UP. MOREOVER, IF AN ORBITER WERE LOST, WE COULD NEVER CATCH UP. THE SELECTION OF THE TITAN $34D_7$ GIVES US A LAUNCH VEHICLE WHICH IS COMPLETELY UNASSOCIATED WITH THE SHUTTLE -- NOT BECAUSE WE DESIRE TO GET OFF THE SHUTTLE, BUT RATHER, TO REDUCE THE CHANCES THAT SOME OUTAGE FOR EITHER LAUNCH SYSTEM WILL AFFECT NATIONAL SECURITY PAYLOADS FOR ANY SIGNIFICANT TIME. WE WILL ONLY BE LAUNCHING TWO OF THE COMPLEMENTARY ELVs A YEAR FROM 1988 TO 1992 TO INSURE THE NATION HAS A CONTINUING HEDGE AGAINST THESE DANGEROUS CONSEQUENCES. THIS SAME HEDGE IS ALSO A MEANS OF REDUCING THE CHANCE THAT THE DoD WILL HAVE TO EXERCISE BUMPING RIGHTS FOR NATIONAL SECURITY REASONS, SINCE THE CELVs PROVIDE AN ALTERNATE MEANS OF ACCESS TO SPACE FOR OUR MOST CRITICAL PAYLOADS. INCIDENTALLY, IT SEEMS TO ME THAT THE COMMERCIAL COMMUNITY WILL BECOME EVEN MORE WORRIED ABOUT OUR BUMPING RIGHTS SHOULD THE TIME EVER COME THAT WE MUST SET THAT PRECEDENT AND BUMP A COMMERCIAL FLIGHT. I BELIEVE THAT SUCH AN EVENT WOULD HAVE POTENTIALLY MUCH MORE FAR-REACHING CONSEQUENCES FOR THE FUTURE COMMERCIAL VIABILITY OF THE SHUTTLE THAN ANY IMPACT THE TEN CELVs WILL HAVE ON THE 100 OR SO STS MISSIONS NASA HAS PROJECTED FROM FY 89-93.

LAUNCH DATES OF CRITICAL NATIONAL SECURITY PAYLOADS

THE CURRENT DIRECTION TO MEET AN OCTOBER 1988 LAUNCH DATE IS DRIVEN BY THE LAUNCH NEEDS OF A CRITICAL NATIONAL SECURITY PAYLOAD. DESIGN CONSIDERATIONS OF THAT SATELLITE DRIVE THE URGENT NEED TO

BEGIN PROCUREMENT OF THE CELV NOW. IF THAT SATELLITE IS TO BE CAPABLE OF LAUNCH ON THE SHUTTLE OR A CELV, WE MUST INCORPORATE THE DESIGN PARAMETERS OF THE SELECTED LAUNCH VEHICLE INTO THE DESIGN OF THE SATELLITE NOW.

INDUSTRIAL BASE

IN THE DECEMBER, 1984, JOINT NASA/DoD LAUNCH VEHICLE TECHNOLOGY STUDY, WRITTEN IN RESPONSE TO THE PRESIDENT'S NATIONAL SPACE STRATEGY, BOTH NASA AND DoD MUTUALLY AGREED THAT "THE CURRENTLY DIMINISHED TECHNOLOGY BASE AND THE TREND THAT ESTABLISHED IT CAUSE CONSIDERABLE CONCERN FOR THE FUTURE AND LEAD US (NASA AND DoD) TO CONCLUDE THAT A NATIONAL COMMITMENT TO A VIGOROUS RESEARCH, TECHNOLOGY, ADVANCED TECHNOLOGY DEVELOPMENT AND DEMONSTRATION PROGRAM, WITH ADEQUATE CONSIDERATION OF PROVISION FOR MAJOR TEST FACILITIES, IS NECESSARY TO REVITALIZE THE SPACE LAUNCH INDUSTRIAL BASE OF THE NATION." WHEN MR. BEGGS TESTIFIED BEFORE YOU LAST MONTH, HE POINTED OUT THAT IN FY 87 THE SUBCONTRACTORS ON THE STS INDUSTRIAL BASE START TO DISAPPEAR, MAKING THE COSTS TO BEGIN THE FIFTH ORBITER PROHIBITIVE. IN FACT, THE SECOND AND THIRD TIER OF CONTRACTORS FOR THE SHUTTLE ARE ALREADY BEGINNING TO DRY UP. THE SAME PROBLEM IS IMMINENT IN THE NATIONAL INDUSTRIAL BASE FOR EXPENDABLE VEHICLES. OUR MUTUAL CONCERN, THEN, IS ONE OF KEEPING AMERICA IN THE SPACE LAUNCH BUSINESS.

GROWTH CAPABILITY TO MEET LONGER TERM NEEDS

ALL STUDIES CONDUCTED TO DATE INCLUDING NASA, DoD AND THE STRATEGIC DEFENSE INITIATIVE OFFICE, HAVE IDENTIFIED NO VALID REQUIREMENTS, THROUGH AT LEAST THE YEAR 2000, THAT EXCEED THE CAPABILITY EXISTING IN THE STS AND THE CELV. ALL THE CELV CANDIDATES, HOWEVER, DEMONSTRATED SUFFICIENT GROWTH CAPABILITY TO SATISFY ANY UNFORESEEN PAYLOAD NEEDS THAT MIGHT OCCUR BETWEEN NOW AND THE END OF THE CENTURY. THE POTENTIAL NEEDS OF THE STRATEGIC DEFENSE INITIATIVE, THE SPACE STATION, AND ANY NEW DoD SYSTEMS NEED TO BE UNDERSTOOD AND CAREFULLY DEFINED. UNTIL THIS IS DONE, WE MUST NOT COMMIT OUR SCARCE RESOURCES TO A MAJOR DEVELOPMENT PROGRAM TO BUILD A BOOSTER WHICH MIGHT OR MIGHT NOT MEET THE NATION'S NEEDS. THE SPACE SHUTTLE AND THE CELV WILL CLEARLY MEET THE NATION'S NEEDS DURING THE NEXT 15 YEARS, WHILE THE LONGER TERM REQUIREMENTS ARE BEING DEFINED.

COMMERCIALIZATION

THE PRESIDENT'S DIRECTIONS IN HIS SPACE COMMERCIALIZATION POLICY CONCERNING THE COMMERCIALIZATION OF NEW OR GOVERNMENT DEVELOPED ELVs ARE CONSISTENT WITH THE DEVELOPMENT OF LOWER PRICED BOOSTERS WHICH HAVE THE POTENTIAL FOR CAPTURING A SHARE OF THE COMMERCIAL MARKET WHICH IS NOW LEAVING THE SHUTTLE FOR ARIANE. MR. BEGGS POINTED OUT TO YOU THAT IN THE LAST 15 MONTHS, NASA AND ARIANE EACH GAINED 5 NEW CUSTOMERS. BUT AS A NATION, OF COURSE, WE WOULD HAVE

PREFERRED TO HAVE GAINED ALL TEN NEW CUSTOMERS. AS YET, NO OTHER NATION CAN OFFER THE SERVICES OF AN ORBITER. HOWEVER, WHEN THE UNIQUE SERVICES AVAILABLE FROM THE ORBITER ARE NOT NEEDED, THE BUSINESS PROFIT MOTIVE FORCES PEOPLE TO USE LOWER PRICED BOOSTERS, SUCH AS ARIANE. THE CELVs, THOUGH NOT DESIGNED AS COMMERCIAL BOOSTERS, COULD PROVIDE A CONTINUING ELV PRODUCTION LINE TO ALLOW THE NATION TO COMPETE DIRECTLY WITH ARIANE. AS A NATION, THEN, WE WILL BE ABLE TO COMPETE FOR A LARGER SHARE OF THE WORLD'S SPACE LAUNCH BUSINESS.

AND FINALLY:

- SUITABILITY FOR OPERATION IN CRISIS AND CONFLICT

  IN HIS NATIONAL SPACE POLICY, THE PRESIDENT DIRECTED THAT MILITARY SPACE SYSTEMS MUST BE SURVIVABLE. THE CELV PROVIDES A BALANCE TO THE STS CAPABILITIES, AND AN ADDITIONAL DEGREE OF FREEDOM FOR OPERATION IN CRISIS AND CONFLICT UNATTAINABLE WITH A CRITICAL NATIONAL ASSET SUCH AS THE MANNED SHUTTLE.

FOR THESE REASONS, WE BELIEVE THAT THE COMPLEMENTARY ELV IS A NECESSARY STEP. I HAVE COME TO A PERSONAL UNDERSTANDING WITH MR. BEGGS ON THE NEED FOR THESE VEHICLES. THE CELV IS NEITHER DoD'S EXODUS FROM THE SHUTTLE, NOR A CHALLENGE TO THE SHUTTLE. INSTEAD, IT IS PRUDENT PLANNING FOR OUR NATIONAL SECURITY AND IS COMPLETELY CONSISTENT WITH THE

PRESIDENT'S POLICIES AND DIRECTIONS SINCE 1981. LET ME REEMPHASIZE THAT MR. BEGGS AND I AGREED, AND SUBSEQUENTLY THE PRESIDENT DIRECTED IN HIS NATIONAL SECURITY LAUNCH STRATEGY ON 25 FEBRUARY, 1985, THAT THE DoD WILL FLY AT LEAST ONE THIRD OF THE SHUTTLE FLIGHTS AVAILABLE OVER THE NEXT TEN YEARS. THE MAJORITY OF THE DoD PAYLOADS ARE ALREADY DESIGNED FOR THE SHUTTLE, AND SOME ARE OPTIMIZED TO USE THE UNIQUE FEATURES OF THE SHUTTLE.

THE REQUIREMENTS WHICH RESULTED IN THE CELV COMPETITION ALL HINGE ON SOME BASIS OTHER THAN COST EFFECTIVENESS. I THINK WE ARE MAKING A FUNDAMENTAL ERROR IN DEFENDING THE USE OF SHUTTLE BASED ON A COST EFFECTIVENESS ARGUMENT. SHUTTLE IS UNIQUE IN ALL THE WORLD, AT PRESENT. IT OFFERS UNIQUE CAPABILITIES AND FEATURES UNAVAILABLE ANY OTHER WAY, AND WE SHOULD BE PROMOTING SHUTTLE BASED ON THESE CAPABILITIES. NASA HAS A BRILLIANT STRING OF SUCCESSES IN DEMONSTRATING THE NEW CAPABILITIES OF THE SHUTTLE. COUPLING THE SHUTTLE WITH THE SPACE STATION WILL FURTHER ENHANCE THE ROBUSTNESS OF THE MANNED SPACE INFRASTRUCTURE NASA IS PURSUING. BOTH PROJECTS WILL BE HIGHLY VISIBLE ASSETS -- ELEMENTS OF NATIONAL PRESTIGE MAKING VALUABLE CONTRIBUTIONS TO SPACE SCIENCE AND MANUFACTURING. THE SHUTTLE IS MOST EFFECTIVE WHEN IT IS USED FOR RETRIEVAL, REFURBISHMENT, SERVICING, REPAIR, AND OTHER SPECIALIZED TASKS WHICH UTILIZE ITS UNIQUE CAPABILITIES TO THE FULLEST. IT HAS MAN'S PRESENCE AND INTELLIGENCE --BOTH FROM INSIDE THE ORBITER, AND WITH THE MANNED MANEUVERING UNIT, FROM OUTSIDE THE ORBITER CARGO

BAY. IN LIGHT OF THE SHUTTLE'S UNPRECEDENTED AND UNMATCHED ABILITIES, OUR NATION HAS NO OTHER WAY TO ACCOMPLISH SUCH SPECIALIZED TASKS. THEREFORE, WE SHOULD NOT TAKE COST EFFECTIVENESS MERELY TO MEAN "CHEAPER." IT MAY MEAN THERE IS NO VIABLE ALTERNATIVE TO PERFORM A TASK. HOWEVER, WHEN A LAUNCH IS INTENDED ONLY TO PLACE A SATELLITE IN ORBIT, AND DOES NOT REQUIRE NOR TAKE ADVANTAGE OF THE CONSIDERABLE BENEFITS WHICH THE SHUTTLE POSSESSES, THEN THE SHUTTLE MAY NOT BE THE MOST COST EFFECTIVE SOLUTION. THE COST EFFECTIVENESS OF TYING UP A MULTI-BILLION DOLLAR SHUTTLE MERELY TO DEPLOY A SINGLE SATELLITE IS VERY QUESTIONABLE. THIS APPROACH IGNORES THE OPPORTUNITY COSTS OF USING SUCH FLIGHTS FOR MORE INNOVATIVE OR HIGHER VALUE MISSIONS. I BELIEVE THAT IN THE ROUTINE DEPLOYMENT CASE, BASED ON THE MEASURE OF COST PER FLIGHT, THE MORE COST EFFECTIVE SOLUTION MAY BE TO USE AN EXPENDABLE BOOSTER. THE EXPENDABLE BOOSTER ALLOWS THE SHUTTLE TO BE USED ELSEWHERE MORE EFFECTIVELY. THUS, THE ONLY CRITERION FOR SUCCESS OF THE STS PROGRAM SHOULD NOT BE THE PERCENTAGE OF THE WORLD'S SPACE LAUNCHES IT PERFORMS. THAT PERCENTAGE SHOULD BE A NATIONAL CONCERN, BASED ON THE TOTAL NUMBER OF COMMERCIAL EXPENDABLE LAUNCHERS AS WELL AS THE NUMBER OF SHUTTLE MISSIONS EACH YEAR.

THE AIR FORCE IS TAKING ANOTHER STEP, ALONG SOMEWHAT DIFFERENT LINES, WHICH IS PRIMARILY RELATED TO COST EFFECTIVENESS. WE HAVE SOME DEFENSE PROGRAMS WHICH REQUIRE SMALL, LAUNCH-ON-DEMAND SATELLITES TO BE INFREQUENTLY PLACED IN LOW ALTITUDE, POLAR ORBITS. WHEN THE PRESIDENT

ANNOUNCED, AS PART OF HIS STRATEGIC MODERNIZATION PROGRAM IN 1981, HIS DECISION TO DEACTIVATE THE TITAN II INTERCONTINENTAL BALLISTIC MISSILES (ICBMs), WE INITIATED A STUDY TO DETERMINE IF THERE WERE A COST EFFECTIVE USE FOR THESE RESIDUAL NATIONAL LAUNCH ASSETS. THE STUDY FOUND THAT THE TITAN II HAD SUFFICIENT PERFORMANCE TO MEET THE LAUNCH NEEDS OF SOME OF THESE DEFENSE PAYLOADS, SUCH AS THE DEFENSE METEOROLOGICAL SATELLITE. THESE PAYLOADS ARE ONES WHICH CLEARLY DO NOT EFFECTIVELY OR EFFICIENTLY USE THE SHUTTLE'S CAPABILITES, AND WHICH DO NOT LEND THEMSELVES TO ROUTINE MIXING WITH OTHER MISSIONS. BASED ON OUR SUCCESSFUL EXPERIENCE WITH THE ATLAS ICBM CONVERSION TO SPACE LAUNCH VEHICLES, WE ARE GOING TO BEGIN REFURBISHMENT OF THE TITAN IIs WHICH WE ARE CURRENTLY DEACTIVATING FROM THREE BASES IN THE UNITED STATES. WE PLAN TO CONVERT THESE TWENTY-FIVE YEAR OLD MISSILES INTO SPACE LAUNCH VEHICLES FOR USE ONLY ON THE WEST COAST, AND FOR LAUNCHES FROM 1988 TO 1995. EMPLOYING TITAN IIs AS LAUNCH VEHICLES RESPONSIBLY USES THE PRIOR NATIONAL INVESTMENT IN THESE MISSILES. RATHER THAN SCRAP THEM, WE WILL GET EFFECTIVE AND EFFICIENT USE FROM THEM, MUCH AS WE HAVE DONE WITH THE OLD ATLAS AND THOR BALLISTIC MISSILES WHEN THEY WERE DEACTIVATED. THE COSTS TO ACCOMPLISH THIS ARE $ 65 MILLION FOR THE INITIAL ENGINEERING AND LAUNCH PAD CONVERSION, AND APPROXIMATELY $ 15 MILLION PER VEHICLE REFURBISHMENT. THE TOTAL COST TO THE TAXPAYER FOR A TITAN II SPACE BOOSTER LAUNCH WILL BE LESS THAN $ 30 MILLION.

THIS DoD INITIATIVE TO USE RATHER THAN SCRAP THESE VALUABLE NATIONAL RESOURCES WAS COMPLETELY REVIEWED IN THE DoD AND OMB, AND IS REFLECTED IN THE FY 86 PRESIDENT'S BUDGET.

THE USE OF THE TITAN II INSTEAD OF A SHUTTLE FOR SUCH PROGRAMS MAKES ECONOMIC AND PROGRAMMATIC SENSE. FOR INSTANCE, THE DEFENSE METEOROLOGICAL SATELLITE'S UNIQUE ORBIT AND LAUNCH-ON-DEMAND SCHEDULE WOULD REQUIRE A DEDICATED SHUTTLE LAUNCH USING LESS THAN 10% OF THE SHUTTLE'S POLAR ORBIT CAPABILITY. THIS WOULD BE AN EXTREMELY INEFFICIENT AND INEFFECTIVE USE OF THE SHUTTLE.

AS A NATION, WE SHOULD HAVE THE MOST VERSATILE AND CAPABLE LAUNCH SYSTEMS ANYWHERE. I BELIEVE WE HAVE THAT OPPORTUNITY FACING US TODAY. WE MUST CREATE AN ENVIRONMENT WHERE THE LAUNCH CAPACITY OF EACH OF OUR SEPARATE SPACE SECTORS -- CIVIL, COMMERCIAL, AND NATIONAL SECURITY -- COMPLEMENT EACH OTHER RATHER THAN COMPETE. WE MUST FOSTER ALL THREE CAPABILITIES AND USE EACH IN ITS MOST ADVANTAGEOUS APPLICATION IF WE ARE TO MAINTAIN OUR NATIONAL SPACE TRANSPORTATION LEADERSHIP.

THIS CONCLUDES MY REMARKS, MR. CHAIRMAN. I WOULD BE HAPPY TO ANSWER ANY QUESTIONS YOU MAY HAVE AT THIS TIME.

Mr. **Nelson**. Thank you very much.

What is the likelihood that by the end of 1992 that DOD would ask to procure and launch more than the currently agreed 10 ELV's?

Mr. **Aldridge**. Sir, there is some uncertainty, and the uncertainty centers around essentially the total mission model that exists for the shuttle. If the Strategic Defense Initiative progresses very well, there could be some additional demands placed upon our launch capabilities for the SDI.

I believe there is some uncertainty as to what pace the shuttle may be used against the space station, and then some uncertainties with regard to total national security needs. Right now I believe we can meet all of these needs with the current shuttle and with the complementary ELV Program.

If, however, the demands for the shuttle would increase beyond the point where we can fly the 24, there is a possibility that we may require some additional expendable launch vehicles beyond the 10. That is not in our plan at this point. We believe that we can meet all of our demands with the current capabilities.

Mr. **Nelson**. What kind of annual flight rate do you think you can get from Vandenberg with the shuttle?

Mr. **Aldridge**. We're planning for about four per year off the shuttle at this time. If we go beyond four per year, we would have to provide for additional facilities at Vandenberg to take up the additional load.

Mr. **Nelson**. What is the minimum number of launches from Vandenberg to maintain your launch crew proficiency?

Mr. **Aldridge**. Well, we'd like to be able to launch off four per year. We'd like to keep that the highest we possibly can. I believe we probably would go to one to two per year would be the minimum that we could get by with. But right now, I think during the initial phases as we build up, I believe we're just planning to launch a few during the first few years at Vandenberg.

But it would have to take one to two per year to keep the proficiency up.

Mr. **Nelson**. Now, over those years of 1987 through 1990, what kind of flight rate are you projecting each year from Vandenberg?

Mr. **Aldridge**. It varies. As we build up, we're running at about three per year in the first few years, on the average, and then climbing to about four per year in the later part of that timeframe. It varies year by year based upon the specific model. But around three to four per year is kind of what our plan is at this point.

Mr. **Nelson**. Now, did you say that you plan the defense weather satellites to go on the shuttle or on the Titan II's?

Mr. **Aldridge**. Right now they're planned to go on the shuttle in 1990. The plan would be that the DMSP's would go on the Titan II's in 1990, as opposed to the shuttle.

Mr. **Nelson**. And how many would that be?

Mr. **Aldridge**. Approximately one per year.

Mr. **Nelson**. One per year after that. But you'd go on the shuttle in 1990?

Mr. **Aldridge**. The plan at this point would be to fly the—the plan was going to be to fly the DMSP on the shuttle in 1990; we are now proposing that we take the DMSP from the shuttle and put it on the Titan II in 1990. And then the DMSP follow-on would go on the shuttle after, sometime in the early 1990's.

Mr. NELSON. Did I see where you were planning five shuttle flights per year?

Mr. ALDRIDGE. In 1992, the plan right now would show 5⅓—the third is the third of a payload bay, which I believe would be a DMSP, according to the model—but about five in 1992, realizing that we'd fly three the prior year.

But you have to put a caveat on all these mission models. We have to manifest the flight rates for the shuttle based upon an anticipated failure date for a particular satellite. We have been very fortunate in this country that many of our satellites last longer than the mean mission duration. So while the manifest in 1992, 7 years away, would show us five, it is very unlikely we would actually be flying five vehicles in that time.

Now, if SDI would begin to build up, we could show as many as eight flying out of Vandenberg in 1992. If that rate were indeed to be correct, we would have to go in and modify the facilities to increase the load at Vandenberg.

Mr. NELSON. When would those SDI and space station payloads start appearing on your manifests?

Mr. ALDRIDGE. Well, they're actually appearing on our manifest now. The President's budget through from 1987 to 1991 includes 10 flights of experimentation-type flights for SDI in the manifest, total, both at Vandenberg and at Kennedy.

The real increase beyond the current plan would show probably in 1992 the uncertainty if we were actually starting toward a deployment mode for SDI. It would pick up about 1992. That's where the eight mission flights out of Vandenberg would come in.

Mr. NELSON. Mr. Aldridge, suppose that I were an enterprising reporter, and I came to you and said, "Now, Mr. Secretary, is it true that the Air Force has spent about $2 billion building Vandenberg as a shuttle facility?"

Mr. ALDRIDGE. That is true.

Mr. NELSON. And then if I were an enterprising reporter, and I said to you, "How can the Air Force justify having spent $2 billion on a shuttle launch facility and now it's going to come back and start launching weather satellites by an ELV?" How would you answer that?

Mr. ALDRIDGE. Well, first of all, the DMSP actually only takes 10 percent of the total shuttle rides. DMSP is not a threat to the shuttle launch rate out of Vandenberg. We had never planned to launch DMSP's on the shuttle until 1990 in any event.

The shuttle facility at Vandenberg goes beyond just the issue of the cost of $2 billion. The type of satellites we launch out of Vandenberg are essential to the national security of this country. You need a Vandenberg facility to launch into polar orbit. You cannot launch into polar orbit out of Kennedy unless you want to overfly Boston or Washington, DC.

So the issue of Vandenberg, it's essential, the cost was worth it to provide that launch capability and also to provide a second launch base for the country to be able to get to space.

So DMSP is not an issue with regard to Vandenberg, because it takes such a small percentage of the payload of the shuttle.

Mr. NELSON. All right. Let me question that a little bit. What about loading up the shuttle bay with things such as cameras, a SIR-B radar, materials-processing experiments that could share that cargo bay with the weather satellite? Would that be an efficient use of the orbiter?

Mr. ALDRIDGE. That was how we were planning to use the orbiter at the time when we only had the option of flying DMSP on the shuttle. We were going to provide, and pay for, about a third of the shuttle costs, even though that's far beyond the capacity, the capability that would be far beyond the weight that the DMSP would use of the orbiter. And we were making the assumption that in fact there would be other users who would pay for the additional two-thirds of the flights. That was what our plan was until we now have this option.

The Titan II is a much more effective use for the DMSP satellite because it is already designed to fly on an expendable launcher. We were going to have to pay about a $70 million integration cost to put the DMSP into the shuttle bay, that we no longer have to pay.

The DMSP fits on the Titan II. It can be launched out of Vandenberg efficiently. It's designed to be a launch-on-demand type of launch; we launch to replace a failed DMSP satellite so that we can wait for when the satellite fails with a booster available and launch it whenever it's available.

With the shuttle, it's very inefficient because you have to plan for the orbiter to be available at Vandenberg when you need to launch. Therefore, we could have to have a call-up capability. We could not sit waiting for the DMSP to fail with an orbiter sitting on the pad with all the payloads waiting for the DMSP to fail. We would have to have some type of capability to have the DMSP and these payloads available somewhere to rapidly integrate and launch. I don't believe that's an effective utilization for the orbiter for a small payload such as this.

Given that the Titan II is now available, it's much more effective and efficient for us to use that capability out of Vandenberg rather than to have a launch-on-demand capability for the orbiter with those additional payloads.

The issue is, yes, we can make that work; it's not the most effective way and most cost-effective way to get the DMSP launched.

Mr. NELSON. So you're going to spend about $65 million to develop and convert the Titan II's?

Mr. ALDRIDGE. Sir, it's a development cost——

Mr. NELSON. Is that a one-time cost?

Mr. ALDRIDGE. That's a one-time cost. That is in constant '85 dollars. It's the cost to develop the shroud and the integration for the payload onto the Titan, and then there will be a $15 million per vehicle refurbishment cost—that includes test firing the engines as we do on the old Atlas-E's today—and checking to make sure it's qualified and reliable. And then the cost per launch includes about a $15 million a year per launch, which is the cost of the pad and the operations of the launch crews.

Mr. NELSON. So you said the total cost to the taxpayer then is about $30 million?

Mr. ALDRIDGE. $30 million per launch.

Mr. NELSON. Per launch.

Mr. **Aldridge**. After the $65 million one-time investment.

Mr. **Nelson**. I see. And if you were going on the shuttle, you'd have an upfront cost, you said, of about $70 million——

Mr. **Aldridge**. $70 million.

Mr. **Nelson** [continuing]. To integrate——

Mr. **Aldridge**. Yes, sir.

Mr. **Aldridge** [continuing]. So that it could go on the shuttle. All right.

Mr. **Aldridge**. The plan right now, Mr. Chairman, is to convert about 12 of the 56 available Titan II's for this purpose, which would include some classified payloads as well as the DMSP.

Mr. **Nelson**. Why don't we talk just a little bit for the record about a fifth orbiter. What is the Air Force's current position on the need for the fifth orbiter?

Mr. **Aldridge**. Sir, the position on the fifth orbiter has to be based upon the overall mission model of the Nation. As I guess I have testified before this committee now 3 years in a row, while we believe that there may be the need for a fifth orbiter based upon an overall mission model, it's up to NASA to justify it for the Nation.

We in DOD cannot justify a fifth orbiter for our purposes exclusively. We believe our needs could be met by the current mission capability of the four-orbiter fleet, plus, of course, the complementary ELV.

However, in looking at the mission demands that could occur as a result of DOD's continued emphasis on space for our national security, the possibility for the Strategic Defense Initiative adding to the mission requirements, the question of the value of the space station and the impact it may have on the orbiter, it may be that NASA could justify the role of a fifth orbiter based upon these new demands. That's up to NASA, however, to present that case from a national perspective.

Mr. **Nelson**. Well, would we, in your opinion, be in a world of hurt if we had one or two of the orbiters inactive?

Mr. **Aldridge**. Yes, sir, I believe we would. Of course, one of the purposes to avoid that catastrophic effect of a complementary ELV was to give us the ability to at least have a production base for additional access to space if such an event occurred.

Mr. **Nelson**. But you still just don't go over that basic decision that you all are willing to step out for a fifth orbiter, if for no other reason than having some backup insurance?

Mr. **Aldridge**. It's hard to make a case that the Defense Department can step up to a fifth orbiter. And the main reason is because the overall mission model has to justify the fifth orbiter. We're continuing with our commitment now to only one-third of the total flights. If that continues to be the case, with our bumping rights against commercial and civil users, we can meet our mission demands with four orbiters.

We're concerned from an overall point of view if the Nation has to make sure that those four orbiters work and are effective for us, but with only one-third of the missions, I cannot defend the Defense Department position that says we need to support a fifth orbiter.

Mr. **Nelson** And certainly not pay for it.

Mr. **Aldridge**. And certainly not pay for it.

Mr. **Nelson**. When do you think that research and development efforts should begin on a large shuttle-derived ELV or the next generation space shuttle?

Mr. **Aldridge**. Part of our agreement with NASA is that we will begin studying the requirements for such a thing immediately. We believe that there is a need to begin the technology as soon as we can. That could lead to the development of such a vehicle sometime in the future, and we ought to begin working on those technologies now. Those technologies will be the type that would give us improved capabilities as well as reducing the cost to get to space.

And I say "technologies" from a very broad perspective. It's not just the technologies of engines and structures and avionics, but it's the technologies associated with logistics as well, because we cannot afford standing armies of people waiting to launch vehicles. We've got to get the costs down, and that's another way we can get those costs down.

So I think we need to take a broad look at a technology base that will get us into the future launch capabilities that cut the cost as well as improve our capabilities. And part of our agreement, as I mentioned, is we're beginning to work right now, as a matter of fact, on the terms of reference for this joint study between ourselves and NASA that will get us on to developing this second-generation system.

I try to say "system" because I don't mean second-generation orbiter. I believe the space transportation system for the future should consist of both manned and unmanned vehicles and in various sizes and weights, so that we don't have to worry, as we are today, of shuttles, and Titan-II's, and complementary ELV's. Maybe the system is composed of elements that are designed from the beginning to meet all of the concerns and demands from all the users' point of view. And that's the kind of study we need to get on with right now.

Mr. **Nelson**. When do you think the development, the actual production of that kind of vehicle might come? Do you have any idea?

Mr. **Aldridge**. Sir, I believe that—of course, the question is when you start it is depending on when the requirement exists. Right now, as a result of the joint study we did and just submitted to Congress, we can't define any requirements for a heavy-lift vehicle in the foreseeable future.

I think we all inherently believe, intuitively believe, we'll need such a capability in the future, but we can't identify the timeframe of when that will occur. However, mid-1990's, toward the year 2000, I think those kind of requirements will occur, which means that you ought to back up and say the development ought to start some period of time.

However, the problem with boosters is that you can build the booster to launch the satellite faster than you can build the satellite. So once we've defined what the payload is going to be, I believe then we can start the booster development and match it in an acceptable way.

Mr. **Nelson**. And how would you conceive that the Department of Defense would participate in the funding of such a joint venture?

Mr. Aldridge. Depending on, obviously, the requirements. If the military requirements are dominating, I think we would share with a great percentage of the funds. As part of the agreement between ourselves and NASA, we anticipate that the Air Force and DOD will essentially pay for the development of unmanned launch vehicles and let NASA be involved with the manned systems—the civil manned systems, in any event. But I think we would have a significant share of the cost of those developments.

Mr. Nelson. Mr. Secretary, you said earlier that you were absolutely delighted with the cooperation between NASA and the Air Force on this launch——

Mr. Aldridge. Yes, sir.

Mr. Nelson [continuing]. That occurred earlier—I lose track of time—earlier this year, I think.

Mr. Aldridge. That's January 24, 1985.

Mr. Nelson. Yes.

Mr. Aldridge. I remember it intimately. [Laughter.]

Mr. Nelson. Did that degree of cooperation and did the degree of the Air Force's hands-on experience, did that lead you to break any myths or have any changed conclusions or to change any of your views about the shuttle and its adequacy?

Mr. Aldridge. No, sir, I always believed the shuttle was adequate. It has to be adequate for our needs. We have always been, in spite of the perceptions that may have occurred in the newspapers or other rumors about the Hill and the Pentagon and Washington, we've always been very happy with the reliability of the shuttle. I have never said that we were concerned about shuttle reliability. Our concern was the concern of our confidence in being able to get to space, and we felt we need a variety of launch vehicles in order to get there.

The purpose for me stating the cooperation is that it truly existed. And I think there is a misconception around particularly in Washington that there is some type of war going on between NASA and the Department of Defense or NASA and the Air Force in particular. And that just doesn't exist, and I wanted to state it for the record that we were very pleased.

The people in the field who had the responsibility of launching 51C at Kennedy and at Houston were just delighted with the spirit of cooperation that existed. And I think it's one of those things that we're proud of that we can in fact work that way. And I think people were very pleased and gave us, I guess, a renewed confidence that we could continue on with that kind of coperation.

Mr. Nelson. You know, we've been going through this exercise about shuttle pricing.

Mr. Aldridge. Yes, sir.

Mr. Nelson. And we basically decided in this committee that we were going to get involved in the act and we were going to understand this thing and we were going to draw some conclusions. And I would be happy to receive your ideas and advice for us.

Mr. Aldridge. Well, sir, you've got a bear by the tail, let me tell you, to get involved with that kind of an issue. We, of course, have been working with NASA for the past many years trying to develop—and we have—but a principle, I believe, in shuttle pricing policy that we're happy with. The principle that we've agreed to is that basically a partnership exists between NASA and the Air Force and therefore a certain amount of the costs of the shuttle, such as Vandenberg and Kennedy, we will pay for individually and we won't put that as part of the price.

The principle that we've agreed to is that basically we pay NASA back for its expendable elements of the shuttle, its costs to fly; that is, the external tank, the refurbishment of the solid rocket boosters, the fuels, and things like that.

We believe that's a fair principle, independent of what it costs. And I have told Jim Beggs that, and our memo of agreement states that, that the principle is we'll pay what a fair price to fly is and not put in the manpower costs and the overhead and stuff like that that both of us have to pay. That's outside. Now, they apply that to commercial users, which is a different issue.

So we're fairly happy with that principle, and we'll just negotiate whatever year after year for that particular thing.

I think what your question dealt with was primarily the cost to the price of the shuttle as charged to commercial users from that point of view. But let me put the first issue aside. Basically, Government users costs are paid by the taxpayer. It doesn't make any difference whether it's in NASA's budget or DOD's budget, it's a cost to the taxpayer to launch Government satellites. And the principle again that we've talked about, we're fairly happy with.

When addressing the issue of price to commercial users, that's a very much more complex subject, one that I try to avoid at all costs if I can, but unfortunately you've asked me the question. I believe we should make it as attractive as we possibly can to attract users to the shuttle. I think it's good for the shuttle program, I think it's good for the Nation, I think it's good for everyone involved to encourage more people to use the shuttle, so long as we don't use up the capacity to launch the Government's satellites.

As a matter of fact, I think it would be just delightful if next year I appeared before this committee and said that we need to buy 10 more ELV's because we've filled up all the spaces on the shuttle but 24 flights a year and we need to get more satellites in orbit and we need more of the ELV's. I think it would be a great environment to be in at that point in time.

Mr. NELSON. What about saying at that point that we need a fifth and a sixth orbiter?

Mr. ALDRIDGE. At that point I believe, I think, you could need anything. And it may be that a fifth orbiter might be the answer. However, numbers of orbiters have to go along with facilities to support them, and maybe what you need is more facilities at Kennedy to turn the orbiters that we've got around rather than a fifth orbiter, or maybe combinations of those two. But, yes, it could possibly be under those conditions.

But I believe that we ought to encourage more people to come on the orbiter, and that may be the price that you charge to a commercial firm has to be competitive with the other alternatives, and maybe getting the price down is the right direction as opposed to driving it up. But I think that has to be looked at from a point of view of the national perspective, and it's something that goes beyond just DOD's view.

Mr. NELSON. Do you have a dollar figure in mind?

Mr. **Aldridge**. A dollar figure in mind? I don't personally. It's hard in any given year to put a dollar figure. I really don't.

Mr. **Nelson**. All right. Let me ask you about the DOD payments to NASA. In this agreement that you struck with Jim Beggs, is there like a retainer fee that you pay at the beginning of the year and it's *x* number of dollars and then there's an additional fee that you pay each flight?

Mr. **Aldridge**. Yes, sir. Let me give you my understanding at this time, and I believe it's consistent with what Mr. Beggs is going to propose to us; and that is, part of the agreement, he would actually give us a specific proposal of how to implement such a plan by the 15th of April. That was called for in the National Security Directive. So I am speaking in general terms of my understanding and, I believe, his understanding of what's required.

First of all, we would agree to essentially a flight rate charge for the shuttle, which as long as the principle is valid I have no problem with whatever that rate or that charge would be. And then based upon that flight rate and the number of flights we plan to fly that year, there would be a certain amount of dollars allocated in the defense budget transferred to NASA for that purpose.

But that flight rate would consist of two components: essentially a fixed rate and a variable rate. And the fixed rate, let's say just for the purpose of illustration, would be half of the flight charge; the total flight charge we've agreed to would be paid to NASA in the beginning of the year independent of how many flights we actually flew.

Therefore, the variable rate would then be expended, given to NASA according to how many, at the per flight charge or per flight time. If, for example, DOD decided in the beginning of the year as an example, "Gee, it would be great if we could find another mission to fly," and the incentive therefore would be the fixed rate is already paid, the variable rate is now what would be charged for the additional flight, which would be a very good bargain for us, and therefore give us the positive incentive in order to fly as many flights as we can beyond that fixed amount of money or the year-by-year amount of money.

There is a negative incentive as well: Don't cancel a flight, because you have therefore lost the fixed rate and that is nonrecoverable. So there is an incentive to add, there is a disincentive to cancel.

Now, if we're late, that's OK because both NASA and DOD could be late in their payloads and we would just be given a credit for the next year. We've already paid the fixed rate and we'll just pay the variable rate whenever we flew. So lateness doesn't have any negative impact on us because both sides could be late.

So I think that's basically the type of agreement that we're going to try to get to, and there is a lot of specifics in there about what is that fixed rate and variable rates. But I believe that's the kind of concept which gives us the right incentive and also gives NASA the right incentive.

Mr. **Nelson**. Now, when do you decide what percentage of the total cost that the Air Force will pay, what percentage of that is going to be a fixed rate and what percentage a variable rate? When do you decide that?

Mr. **Aldridge**. As soon as we get the proposal from NASA, we will sit down with NASA to begin the negotiations for that particular breakout of factors. I don't know, it could be 50 percent, it could be 30 percent. I really don't know at this point.

Mr. **Nelson**. OK. You know it's not much of an incentive if you decide that your fixed rate is going to be 1 percent.

Mr. **Aldridge**. No, the incentive for NASA is to drive that up as much as possible. And, of course, that's OK with us in some sense, as long as we agreed to what the flight charge is going to be and it's a reasonable flight charge. The fact of the matter is it's a good incentive anyway because if it's 99 percent fixed rate and 1 percent variable, then that's a very attractive price for us to keep adding shuttle missions if we could. Of course, it's a disincentive to cancel it because you don't lose much, though.

Mr. **Nelson**. Let me just ask you this one other question. Back at the time when you were talking about complementary ELV's, you said that you must have that alternative assured vehicle for access to space. Now, if I recall, don't you have the Centaur as the upper stage on this new modified Titan ELV?

Mr. **Aldridge**. Yes, sir. The plan is to have essentially a shuttle launch capacity to geosynchronous orbit of 10,000 pounds, and that requires a Centaur-type vehicle for that type of purpose.

Mr. **Nelson**. And the Centaur is also the second stage on the shuttle.

Mr. **Aldridge**. For some satellites, not for all. Some satellites don't require upper stages at all, those going into low Earth orbit. Some satellites have internal propulsion, which don't require an upper stage. Some have IUS's and some have Centaurs.

Mr. **Nelson**. But the ones that would be going up in the modified Titan would be going on a Centaur upper stage?

Mr. **Aldridge**. Yes, sir.

Mr. **Nelson**. And what I am wondering here, if you're concerned about the assured access to space, you've got a common second stage, and don't you get concerned that you might have a common failure mode there about getting up to where you need when you have to have assured access?

Mr. **Aldridge**. Well, yes, but the problem of assured access was mostly concerned with the orbiter being the only assured access, where if you lost an orbiter you've lost 25 percent of your total launch capacity, or if you've grounded the orbiter fleet you've lost it all.

That was the single-thread access we were worried about, not with upper stages, because upper stages only associated with a single satellite and that our access to space with upper stages is associated with the fact we don't need upper stages for some satellites, internal propulsion for others, IUS's for others, and Centaurs for others.

So your access to space with upper stages, that's only one part of your capability to get to space. If Centaur failed, I have got many other ways for getting launched. If shuttle fails or is grounded, I have no other way. That was my concern.

Mr. **Nelson**. Mr. Volkmer.

Mr. **Volkmer**. Thank you, Mr. Chairman.

I would like to address another matter, Secretary Aldridge, and that is, the shuttle operations and planning complex, and that is, where we are on it, where we're planning to go. I suppose after listening to the question of the chairman about your shuttle launch in January, that you are satisfied with JSC also?

Mr. ALDRIDGE. Yes, sir, we were.

Mr. VOLKMER. Now, why do we have the proposal for Colorado Springs? That's a basic question.

Mr. ALDRIDGE. Yes, sir. There are two aspects of the Colorado Springs facility, which is the Consolidated Space Operation Center.

Mr. VOLKMER. Right.

Mr. ALDRIDGE. One part of it is the satellite operations side, which are used to back up the Sunnyvale facility for operating satellites. We were looking for a redundant complex to ensure that we had the continuous capability to operate satellites and we weren't dependent upon a single facility, which so happens to be sitting on the San Andreas Fault right adjacent to the freeway going to San Francisco. And the concern was that if something would happen to that facility, we would lose our ability to control satellites.

So part of the Consolidated Space Operations Center was to provide the backup capability for satellite operation. That is proceeding well. It's pretty much on track, and I think there has been very little argument as to the need for such a capability.

Mr. VOLKMER. Nobody would——

Mr. ALDRIDGE. The second part of it was the Shuttle Operational Planning Complex [SOPC] part of the CSOC, which would back up the Johnson Space Flight Center in Houston when the number of flights of the DOD would increase to the point where Johnson could not provide for the continued operation of their civil missions as well as carry the increased workload for the DOD missions and provide a secure facility for the planning and execution of the DOD missions.

As you know, now Johnson cannot accept shuttle flights which are combined classified and unclassified missions. The complex at Colorado Springs would, in fact, be designed so that it could fly mixed missions on DOD missions. They could do that and provide the basic secure facility.

However, as the shuttle rates have been decreased with time, we have delayed the implementation of the shuttle operation and planning complex until like the early 1990's, but basically it's the facility that provides the additional backup to Johnson, which is also single noded, and provides the secure military complex for flying the orbiters when the rate gets to a high rate in the early 1990's.

Mr. VOLKMER. I understand that you have already gone into phase I contract for design specs. Do you envision replicating the JSC systems?

Mr. ALDRIDGE. Sir, we're hoping to build upon some of the basic functions of Johnson, because the basic missions to be flown out of the shuttle and operational planning complex would be the same. Yes, the software would be similar, the computers and displays would be similar. So we hope to build upon their experience rather than have to go with a different direction.

Mr. Volkmer. Are you contemplating using DOD ADA language then?

Mr. Aldridge. I don't believe that decision has been made at this point in time.

Mr. Volkmer. Well, won't you have problems with it if you replicate JSC?

Mr. Aldridge. I am not sure. I think we would have problems if we didn't build upon JSC's experience, because I don't believe the Air Force ought to have to pay for something like that.

Mr. Volkmer. All right. You said, "build upon." I guess that's basically a clear signal that basically you're not really just replicating what they have down there then.

Mr. Aldridge. I believe there is more to it than just replicating. However, Johnson is going through a modernization program with the equipment that's at Johnson. And it is my understanding that the Air Force plans to use basically that same type of equipment for the SOPC. The question is, what additional equipment is needed because of the unique secure operations and planning operations that the SOPC has. And I am not clear that I know exactly the details of what additional equipment may be required.

That's the result, incidentally, of the studies that are ongoing right now by the contractors in defining what it is a SOPC, what does it look like, and exactly how much is it going to cost to implement the program.

Mr. Volkmer. And also, I guess, what we get down to is if you basically build in the same type and design as what we have, using the same hardware and software, we're building in the same contractors.

Mr. Aldridge. That's not necessarily true, sir. We could go second-sourcing. We could reopen the bid based upon the designs. But it doesn't necessarily mean the same contractors.

Mr. Volkmer. All right.

Mr. Aldridge. I don't think that decision has been made at this point.

Mr. Volkmer. OK. Well, we will try to follow it pretty closely.

The second thing that enters into the last part of it is, ultimately, as the Shuttle Operations and Planning Complex, the SOPC, are we going to see DOD operations solely out of there?

Mr. Aldridge. That is the intent, much like today, where NASA launches a payload out of Kennedy, the operations shift to Johnson as it clears the gantry. If we're flying a DOD payload out of Kennedy or at Vandenberg for military payloads, as it clears the gantry, control would shift to the CSOC at Colorado Springs, yes, sir.

Mr. Volkmer. Thank you.

Thank you very much, Mr. Chairman.

Mr. Nelson. Thank you, Mr. Volkmer.

Thank you, Mr. Aldridge.

Mr. Aldridge. Thank you, Mr. Chairman.

Mr. Nelson. Excellent testimony. Thank you for your insights.

Mr. Aldridge. Thank you, sir.

Mr. Nelson. We appreciate it. You have a good day.

Ms. Dorn.

We welcome for the second time this week Ms. Jennifer Dorn, Director of the Office of Commercial Space Transportation at the Department of Transportation.

Ms. **Dorn**. Good morning, Mr. Chairman.

Mr. **Nelson**. Good afternoon.

Ms. **Dorn**. Oh, pardon me.

Mr. **Nelson**. Sorry you have had to wait so long.

Ms. **Dorn**. That's fine.

Mr. **Nelson**. It seems to be our propensity to have long hearings. But it's all so interesting.

This office, your office, was created as a result of the Commercial Space Launch Act, which was enacted last October. So we are glad to welcome you for your first formal budget request to the Congress and to learn of the status of implementation and other activities that are associated with the Commercial Space Launch Act.

STATEMENT OF JENNIFER L. DORN, DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION, U.S. DEPARTMENT OF TRANSPORTATION

Ms. **Dorn**. Thank you. I am happy to be here, Mr. Chairman.

I have submitted for the record a lengthier statement which indicates in more detail some of the activites of the office. So I would just like to go over briefly some major concepts to give you an idea of how we have intended to comply with the conditions of the Commercial Space Act.

We at the Department of Transportation, Mr. Chairman, are proud of the progress that we've made to date in helping to streamline the Federal regulation of commercial space transportation activities and cutting the redtape that was identified by this committee as one of the chief impediments to private sector success.

In many cases, our role could best be described as that of an honest broker, in clearing the way for both efficient industry operations and effective Government oversight. I would just like to give you a couple of examples of the kinds of things that we have done over the past few months.

First of all, we assisted in the coordination of the Federal approval of a suborbital launch request off of the coast of California. Now, obviously, the fact that it is a suborbital launch without a payload makes it seem a bit easier to go along with the regulatory process. However, we discovered it was a process that required the same level of effort in terms of negotiation and clearances as any more complicated launch, of any length, whether it had a payload or didn't have a payload.

In addition, we defined and greatly streamlined the process by which companies can obtain a launch license, with the cooperation and assistance of other agencies, NASA particularly and the Departments of Commerce, Defense, and Space.

We have issued, within just 40 days, our first mission approval, which I will discuss in more detail later, for new use of space. And we have assisted companies in their interactions with other agencies in policy areas related to commercial launch operations, such things as technology transfer, insurance, range use, and other matters.

We have also recently issued a policy statement which provides the public with guidance as to how the regulatory process will operate. This is designed to let industry know what they can expect in the way of information requirements as well as the timing of future regulatory guidance.

In our efforts, then, we have followed two main guidelines: The first, that the licensing policy be conducted in a manner which is fully consistent with the public safety, national security, and foreign policy requirements of the United States; and second of all, that we impose regulatory restrictions only to the extent necessary to protect those interests.

Our regulatory framework encompasses two specialized review processes: Mission review, and launch safety review. These reviews can be conducted independently and in any order, either sequentially or concurrently, depending on the nature of the specific launch and the need of the company making the request. In all of our efforts, Mr. Chairman, we have tried to have as much flexibility as possible to respond to the needs of a new and growing industry.

Mission review is the mechanism for considering the proposed launch activity in the context of its implications for the international and national security interests of the United States. In this review, the Department and other agencies examine the objective of the proposed launch and the means by which the company proposes to accomplish that objective.

The second part of the licensing process then is the launch safety review, which addresses the range and vehicle safety resources an applicant can assemble to guarantee safe launch operations.

Now, in the majority of cases, Mr. Chairman, that launch safety review will be almost a pro forma type of consideration because most of the launch companies to date will be using existing national range facilities. It's only in the future where other commercial ventures may seek to launch from sites other than the national range that it may become a bit more complex in terms of how we arrange the licensing.

Specifically, that review focuses on such factors as the suitability of the proposed launch site and flight path, the safety expertise of range personnel, ground and flight safety process and procedures, range tracking, and instrumentation capability, vehicle safety systems, and vehicle design.

Two of our other major areas of responsibility include issuing regulations on third-party liability, including an advance notice of proposed rulemaking to examine the issues, which will be published shortly, and establishing commercial launch sites, which I mentioned a moment ago.

Mr. Chairman, one of the factors that has made our job at the Office of Commercial Space Transportation much easier is the careful attention Congress has paid to this issue and the clear direction it has given to our efforts. Our goal in implementing the Commercial Space Launch Act has been to be responsive to industry needs, to provide creative approaches to solving problems, and to establish a network of supportive professionals across all of the agencies who have a role in this endeavor.

And I must say, with that in mind, Mr. Chairman, that the Department has faced an incredible amount of cooperation on the part of all of our sister agencies with whom we have worked, particularly NASA and the Air Force, who have worked closely in a number of our endeavors and who have been of great assistance in the technological area as well as the policy area in order to deregulate an industry that was having some trouble with cumbersome regulations.

We view the facilitation of the commercial launch industry as an important component of America's space transportation program. This committee's leadership and assistance will continue to be of critical importance in our efforts to implement the goals articulated in the legislation.

We look forward to your continued support.

[The prepared statement of Ms. Dorn follows:]

Statement of

Jennifer L. Dorn
Director, Office of Commercial Space Transportation
U.S. Department of Transportation

before the

Subcommittee on Space Science and Applications
U.S. House of Representatives

March 7, 1985

I want to thank the Chairman and members of the Subcommittee for this opportunity to appear before you today to report on the progress of the Department of Transportation in streamlining Federal regulation of commercial space transportation in ways which promote, encourage and facilitate launch activities by the private sector.

Mr. Chairman, one of the factors that has made our job at the Office of Commercial Space Transportation much easier is the careful attention Congress has paid to this issue and the clear direction it has given to our efforts. Working to develop licensing procedures and other appropriate regulations to implement intent the of the Commercial Space Launch Act provisions has served only to increase our appreciation for the very real achievement of this Subcommittee and its staff, in cooperation with the Senate Commerce Committee. Despite the unusually brief time available to develop the bill, the Subcommittee can take justifiable pride in having fashioned a regulatory structure that both protects legitimate interests of the United States and at the same time is responsive to the industry's needs.

In the four months that have passed since enactment of this legislation we have witnessed a number of developments in commercial space transportation that indicate confidence in the commercial launch industry and in its potential. I doubt that anyone can predict with certainty either the nature of the contribution that private commercial launch firms will eventually make to America's space effort or the amount of time that will pass before the extent of that contribution becomes fully apparent. Nonetheless, the determined commitment of private launch firms to establish themselves in the exciting field of space commercialization provides testimony to the fact that commercial ELVs can play an important role in providing this Nation with access to space.

As part of my report to you this morning, I would like to focus on how the Department of Transportation is acting to fulfill Congress' intent, as embodied in the 1984 Act and our progress in meeting the objectives that have been set in this regard.

Industry Developments

Despite the regulatory obstacles recognized by the President and this Committee at the outset and the relatively short period of time since the ELV commercialization effort started in earnest, private launch firms have already begun to make some significant gains. US ELV firms have been making serious and sustained efforts to promote their products and services in domestic and international markets. Transpace Carriers, Inc. (TCI), and General Dynamics have been marketing their launch services to potential launch customers around the world. SSI, one of the smaller and newer entrants to the industry, has been successful in attracting customers whose payloads requirements are typically smaller than those serviced by existing ELVs and the Shuttle.

Interagency Activities

The Office of Commercial Space Transportation has participated in various policy making forums, both as a member of the Senior Interagency Group on Space, chaired by the National Security Council, and the Cabinet Council on Commerce and Trade. Its role has been to contribute to the establishment of a space strategy and to evaluate initiatives that promote and encourage rivate sector participation in commercial space endeavors, approved by the President on July 17, 1984. In addition, we have worked successfully with other executive agencies to establish a pricing policy for the commercial use of national range facilities and services. The direct cost pricing policy that has been adopted by the Department of Defense implements the intent of the National Security Decision Directive to promote the use of national ranges and sets charges for such use at a level comparable to that assessed government users. We are also working with the Departments of State and Commerce, the U.S. Trade Representative, and NASA to develop policies to increase the competitiveness of U.S. commercial ELVs on the world market.

Advisory Committee on Commercial Space Transportation

Mr. Chairman, I am also pleased to be able to report, that Secretary Dole convened the first meeting of the Department's Advisory Committee on Commercial Space Transportation in October of last year. We feel especially fortunate that industry leaders in all phases of private commercialization of space have agreed to contribute their time and expertise to assist the Department's efforts to adopt policies that will encourage the growth and development of this industry. The committee's membership has been designed to include representatives from both large and small, new and established launch firms. Members have also been drawn from the investment banking, insurance, and satellite industries, and from public groups with an interest in space commercialization.

We believe that the advisory committee's expertise and insights will provide an invaluable complement to the work of our own staff in the Office of Commercial Space Transportation. The committee will hold its second meeting March 25-26 to discuss the launch licensing process and pricing issues.

Regulatory Program

Much of our activity during the past four months has been directed to developing regulatory procedures to implement the licensing requirements specified in the Act. Among the purposes Congress articulated in the Act was the directive to DOT, as lead agency within the Executive Branch, to:

- oversee and coordinate the conduct of commercial launch operations;
- issue and transfer commercial launch licenses authorizing these activities; and
- protect public safety and the national security and foreign policy interests of the United States.

Our initial efforts to comply with this mandate are concentrated upon giving the industry a clear indication of the Federal Government's primary interests and concerns in the area of private commercial space transportation -- that is, the specific regulations agencies will apply to commercial space launches -- as well as an explanation of when and how those interests will be asserted. To this end, we have concentrated on areas in which current and potential industry activities are most numerous or significant and where the need for clear procedural guidance is most clearly evident. These areas involve expeditious consideration of launch license applications and specification by DOT of minimum liability insurance requirements for space launches.

The Office of Commercial Space Transportation is now in the process of issuing specific regulatory guidance in each of these areas. On February 25, we published a Notice of Policy explaining the application process for launch licenses and the interagency coordination process for reviewing license applications. The Notice also indicates the nature and timing of further regulatory guidance the Office will be issuing. A copy of the Notice is attached to the testimony I have submitted.

Because of the Subcommittee's interest, I intend to briefly outline the general nature of the licensing process we have proposed. Beyond doing so, however, I think it important to describe the additional regulations the Office will shortly issue. In this way, Mr. Chairman, I can give you and the other Subcommittee members a more complete picture of the actions now under way

Licensing Process for Private Commercial Launches

We have devoted a great deal of thought and effort to developing a statement of policy which addresses clearly the questions launch firms and other interested parties have concerning the policies and procedures that DOT and other Federal agencies intend to apply in authorizing and supervising private commercial launch activities.

The basis of the licensing policy we propose to adopt is Congress' injunction that commercial launch activities be conducted in a manner fully consistent with the requirements of public safety (including the safety of property), national security and foreign policy. Equally, the policy would be to impose Federal licensing and other regulatory requirements only to the extent necessary to protect those interests. Thus, the central goal of the policy is to realize these objectives within a framework which responds to this emerging industry's needs for both regulatory flexibility and certainty.

The regulatory framework we have designed to accomplish these requirements encompasses two specialized review processes: Mission Review and Launch Safety Review. These reviews may be conducted independently of each other and in the order (either sequential or concurrent) that is more appropriate to the nature of a specific launch.

Mission Review is the mechanism for considering the proposed launch activity in the context of the United States' international obligations as well as our national security and foreign policy interests. DOT is responsible for ensuring that a proposed launch activity, (including the launch of a vehicle, the placement of a payload in space or both) does not constitute a hazard to public health or safety and is not adverse to either U.S. foreign policy or national security interests. DOT has devised the mission review process as the means for addressing these factors.

In the course of a mission review, DOT and other agencies will examine the objective of the proposed launch and the means by which the launcher proposes to accomplish that objective. When we speak of "objective" we mean the reason for having a launch, such as to test a new vehicle or to place a telecommunications satellite in geostationary orbit. When we speak of the "means" for accomplishing the objective, our interest is in elements of the proposal such as the flight plan or the design of the payload. If the payload is one for which a prior Federal approval is required, for example an FCC license, our statute requires us to avoid duplicating the evaluation made of the payload by the responsible Federal Agency.

On the other hand, if the launch activity is directed toward placing a payload in space for which no prior Federal approval is required, DOT and other agencies would have to assess the proposed mission to determine whether the launch should be prevented because the launch of the payload in question would be hazardous to public health or safety or adverse to U.S. foreign policy or national security interests. The proposed launches by Space Services, Inc. of payloads containing cremated remains were reviewed in this manner before mission approval was granted.

The other component of the launch licensing process involves the Launch Safety Review. This inquiry addresses the range and vehicle safety resources an applicant can assemble to guarantee safe launch operations. Specifically, the review will focus on such factors as the suitability of the proposed launch site and flight path, the safety expertise of range personnel, ground and flight safety process and procedures, range tracking and instrumentation capability, vehicle safety systems (including flight termination mechanisms), and proposed vehicle design.

It should be noted that an applicant's choice of the site from which it proposes to conduct a launch can effectively reduce the number of safety issues DOT must address.
If an applicant proposes, for example, to launch from an established national range, where safety requirements governing equipment, personnel qualifications and launch procedures developed by the government operator of the range are already in place, many of the launch safety requirements will be satisfied simply by a statement of intention to launch from that range. The launch license would be conditioned by the requirement that the applicant comply with all applicable safety requirements and procedures of the range. Similarly, once DOT has developed requirements and procedures for licensing private launch sites, an applicant will be able to secure prompt launch safety approval by indicating an intention to utilize such a licensed commercial site.

When a firm has obtained both mission and launch safety approval, DOT will issue a license incorporating certain necessary and appropriate conditions pertaining to the license holders' activities from the time of license issuance through the actual launch. These conditions can be expected to include requirements that the licensee adhere strictly to range safety regulations and procedures that specific safety measures be undertaken, that airspace restrictions be observed, that a specified amount of liability insurance be obtained, and that Federal inspection, verification and enforcement requirements be complied with.

Liability Insurance

Let me turn now to the other elements of our regulatory program. We plan to issue an Advance Notice of Proposed Rulemaking concerning liability insurance issues. The Notice explains -- and requests public comment on -- issues we have identified in the area of liability insurance that we believe the Office will have to address in the process of setting minimum amounts of liability insurance, as required under Section 16 of the Act for specific space launches or for the operation of private launch sites.

We are especially concerned with the area of third party liability for damage caused to persons or property that are not involved with the launch or other space-related activity for which the Office issues a license. Our primary objective here is to ensure that insurance levels are set at a level sufficient to compensate third parties for damage and adequate to cover any liability the United States may incur as a result of the international obligations it has assumed under the 1972 Liability Convention.[1] At the same time, however, we want to be able to set insurance levels that will neither impose inordinate economic burdens on launch firms nor prevent firms from obtaining insurance at reasonable rates. Thus, we will be examining in this rulemaking proceeding the central question of whether DOT should undertake its own analyses of the risks associated with individual space launches or whether we should direct -- as NASA has done for commercial payloads on the Shuttle -- that launch firms purchase the maximum amount of insurance commercially available, or some combination thereof.

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[1] Convention on International Liability for Damage Caused by Space Objects, 24 U.S.T. 2389 (1972).

As the Subcommittee is well aware, liability insurance is only one of many issues the Office of Commercial Space Transportation must consider in the process of licensing nongovernmental space launches. Like the policy statement itself, launch licensing regulations will serve as interim guidance to applicants concerning the requirements for obtaining licenses and the procedures the Office will follow in evaluating their requests for launch approvals.

Licensing Commercial Launch Sites

The other major licensing responsibility committed to the Department involves the operation of private commercial launch sites. The issues presented here are numerous and in many ways more complex. I say this primarily because government and industry are only beginning to identify their respective interests in the operation of commercial launch sites. The Administration has demonstrated and justified its interest in encouraging commercial launch firms to utilize the excellent facilities and extensive expertise available at U.S. Government ranges. Indeed, both NASA and the Air Force are making sincere and significant efforts to assure launch operators that their commercial needs -- especially their near term needs -- can be met effectively on national ranges. While commercial launch firms have been receptive to using these government facilities, some have indicated that private launch sites may suit their needs as well.

My primary concern with regulation of commercial launch sites is that the Federal Government not commit itself to a rigid regulatory approach too far in advance of actual development of this segment of the industry. We believe that a more responsible approach is to explore and evaluate a variety of regulatory steps that can accommodate operational flexibility and yet ensure safe operations.

With this goal in mind, the Office of Commercial Space Transportation will initiate studies of regulatory alternatives which will support our licensing operations at private launch sites. We in cooperation with other Federal Government agencies, are considering issuing performance standards for private launch site operations and challenging the industry to develop appropriate procedures for meeting these standards. We are also paying a great deal of attention to methods for encouraging the development of launch safety expertise in the private sector. These include possible certification of launch safety inspectors as well as personnel capable of monitoring launch vehicle assembly and payload integration.

For the reasons stated both here and in the Notice of Policy attached to this statement, we do not believe that issuance of even interim regulations governing operations at private launch sites is an objective we can responsibly achieve within the 180 day period contemplated by the Act. We hope, nonetheless, to be able to publish within that period a formal document on this subject. This document will specify the issues we believe must be addressed before specific regulations can be drafted. It also will identify the regulatory alternatives we think are available to us to fulfill Congress' intent that commercial launch sites are operated responsibly.

Resource Issues

Let me turn now to the resources I believe will be required to support the work of the Office of Commercial Space Transportation. As I testified before this Subcommittee last year, the Department has made available the necessary resources to support the activities of this Office within the budget request for the Office of the Secretary.

A core staff has been assembled to carry out the provisions of the President's Executive Order and the Commercial Space Launch Act. Eleven full time permanent positions have been officially assigned to this office, with extensive participation by the staff of the General Counsel's office. In addition, two detailees from the Air Force have been assigned to the Office of Commercial Space Transportation in order to provide technical support in the areas of ELV launch operations and their regulation.

The Department is also enlisting contractor support in the areas of regulatory requirements development, research and alternatives analysis, and the competitive posture of domestic and foreign launch capabilities.

Conclusion

Mr. Chairman, this Committee's leadership assistance has been and will continue to be of critical importance in our efforts to implement the goals articulated in the Commercial Space Launch Act. We view the facilitation of the commercial launch industry as an important component of America's space transportation program. We look forward to your continued interest and support. I will be happy to answer any questions you may have.

federal register

Monday
February 25, 1985

Part IV

Department of Transportation

Office of the Secretary

14 CFR Ch. III

Commercial Space Transportation; Licensing Process for Commercial Space Launch Activities; Notice of Policy and Request for Comments

space of a vehicle and any payload carried by such vehicle by: (A) Any person from the United States, its territories and possessions, including the territorial sea;

(B) A citizen of the United States or a corporate or other entity organized under U.S. or State law, from outside the United States;

(C) A foreign corporate or other entity controlled, as defined pursuant to section 4(11)(c) of the Act, by a citizen of the U.S. or a corporate entity organized under U.S. or State law at any place which is both outside the United States and outside of the territory of any foreign nation when there is no agreement in force between the United States and a foreign nation which provides that such foreign nation shall exercise jurisdiction over such launch; or

(D) A foreign entity, as described in subparagraph (c) above, from the territory of a foreign nation when there is in force an agreement between the United States and such nation concerning the exercise of jurisdiction by the United States over such launch.

The policies and procedures described in this Notice do not apply to Government launches, their payloads, or to the review of Government payloads.

3. *Background*

In 1982, the Federal Government was presented with the first proposal by a private firm to launch an expendable launch vehicle from a private launch site. At that time, a number of Federal agencies claimed either a direct or indirect regulatory interest in the foreign policy, national security, international treaty or public safety issues attending the launch, but no agency appeared to have direct responsibility for licensing the launch itself. Given the uniqueness and urgency of the proposed launch, the Senior Interagency Group (Space) decided that ELV launches would be considered "exports" and thus be subject to the International Traffic in Arms Regulations (ITAR). Utilization of the ITAR to regulate commercial ELV launches was seen as an appropriate, though temporary, expedient for addressing most of the domestic and international issues raised by commercial space launches.

As a regulatory apparatus for authorizing and supervising commercial launch activities, the ITAR proved to have significant limitations. Although the ITAR provided a consultative license approval process for addressing the range of Federal issues raised by private launch activities, none of the Federal agencies responsible for administering regulations applicable to such activities had developed either procedures for reviewing launch applications or criteria for granting approval. As a result, the first private launch applicant was subjected to duplicative reviews and other complications that prolonged the licensing process.

The experience of the first commercial launch applicant created the impetus both for a government-wide effort to devise a more rationalized approach to future launches and for designation of a lead agency to direct that effort. Since its designation as lead agency by Executive Order 12465, DOT has consistently promoted an expedited licensing process that continues to rely on the existing expertise and specialized policy perspective of other Federal agencies. That approach is now mandated by statute. At the same time, DOT's experience in assisting a subsequent launch applicant to obtain Federal approval for its first launch from a site in the Pacific Ocean amply demonstrated that the very nature of the consultative approach to licensing creates a compelling need for a carefully structured and effectively coordinated licensing process.

4. *Licensing Policy for Commercial Space Launch Activities*

A. Statutory Requirements. The Commercial Space Launch Act requires that any person intending to launch a launch vehicle or to operate a launch site within the United States, or any United States citizen intending to launch a launch vehicle or to operate a launch site in circumstances described in section 2 of this Notice, obtain a license from the Secretary of Transportation. The Act authorizes the Secretary to issue or transfer licenses for private space launch activities in a manner consistent with public health and safety, the safety of property, and the national security and foreign policy interests of the United States. It directs the Secretary to issue a license if the Secretary finds that an applicant complies, and will continue to comply, with all applicable requirements imposed by statute and regulation. The Act further directs that conditions that may be necessary to ensure such compliance be incorporated in each license the Secretary issues. Along with the responsibility for protecting public safety and other vital national interests, the Act imposes a concurrent duty on the Secretary to shape a licensing process that facilitates the provision of launch services by the private sector and affords applicants a simplified, expeditious means for securing licenses for launch operations.

B. Licensing Principles. DOT has drawn the basic principles for shaping both the form and substance of its regulatory program from the responsibilities for commercial space launch activities expressly assigned to the Secretary by Congress. The structure of our licensing process must serve, to the extent necessary, the requirements of public safety, national security, and foreign policy as mandated by statute. At the same time DOT's policies and procedures must be formulated in a way that reflects the needs of an emerging industry.

Specifically, the regulatory regime for launch activities must provide firm assurances that such activities not only pose no unreasonable risks to the public but that routine launch activities can in fact be conducted safely. Moreover, a specialized component of the licensing process must focus specific attention on international treaty obligations and the foreign policy and national security dimensions of proposed launch activities. Finally, the Government must oversee launch activities in a manner that provides the industry with the certainty crucial to effective planning and preparation and the flexibility necessary to allow continued growth and innovation.

To meet those responsibilities DOT has developed a licensing process encompassing two distinct components: a Mission Review and a Launch Safety Review (see chart). These reviews may be conducted independently of each other and in the order, sequential or concurrent, that is more appropriate to the nature of the proposed activity and the needs of the applicant.

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Mission Review. Under the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and other Celestial Bodies (the Outer Space Treaty), 18 U.S.T. 2410, 610 U.N.T.S. 205, to which the U.S. is a State Party, non-governmental activities in space require authorization and continuing supervision by the appropriate State Party. Under the Convention on International Liability for Damage Caused by Space Objects (the Liability Convention), 24 U.S.T. 2389, to which the U.S. is also a State Party, the U.S., not private launch entities, agreed to assume liability for damage caused by U.S. space objects in a wide variety of circumstances; these include absolute liability for damage to life and property caused when a space object is launched from U.S. territory or the launch is otherwise conducted or procured by the U.S. This direct liability forms the basis for a broad Federal interest in proposed private space launch activities, one which extends beyond safety issues to include both the purpose of the launch and the nature of the payload. This unique interest in the launch mission distinguishes regulation of commercial space launch activities from regulation of other modes of transportation.

The Mission Review component of the licensing process is intended as the mechanism for addressing these international obligations as well as the national security and foreign policy implications of a given launch. Mission Review focuses on such factors as the purpose and character of the proposed launch, the nature of the payload, and the impact of the launch or payload on existing uses of space. As an example, a payload must not interfere with other spacecraft or endanger other nations. Mission approval will be granted only upon a determination that the launch will not conflict with vital national interests.

Although Mission Review will address certain characteristics of the launch, such as the proposed flight plan, in substantial part Mission Review for an orbital launch will center upon the payload. The payload review can occur in one of two ways. If the payload must be licensed by another Federal agency, such as telecommunications satellites licensed by the Federal Communications Commission or private operational remote sensing satellites licensed by the Department of Commerce, DOT would not duplicate the review undertaken in the course of the license process conducted by such agency. Rather, DOT will accept the license so issued as satisfying the requirements of mission review pertaining to the payload.

Payloads which are not independently licensed will be reviewed by DOT in consultation with the Departments of State and Defense, and, as appropriate, the National Aeronautics and Space Administration and other agencies to ensure that the payload mission does not conflict with national interests.

Launch Safety Review. As with other transportation systems, the Government has a responsibility to protect the public against any unreasonable risks that space launch activities might pose to either life or property. At present, non-Governmental space launch activities rely solely on unmanned vehicles, a characteristic having important implications for safety enforcement. With manned vehicles, as in aviation, rail, or automotive transportation, a strong correlation exists between system reliability and safety: Critical components cannot fail without endangering the human occupant(s). With unmanned vehicles such as ELV's, where system reliability commonly averages between 95 and 98 percent, safety measures can be framed somewhat independently of mission success. In fact, the most common safety measure employed in the event a critical flight component fails entails thrust termination of the launch vehicle in flight by safety personnel monitoring the launch which results in the destruction of the vehicle. Thus, the launch safety component of the licensing process focuses upon the safety elements of the launch operation and the safety systems of the vehicle; reliability of the vehicle in a non-safety context will be the responsibility of the launch vehicle manufacturers.

As the result of more than two decades of federally-sponsored ELV launch operations, standard practices and procedures have evolved to a point where the safe conduct of routine ELV activities can be virtually assured. To date, for example, not a single public fatality has resulted from a space vehicle launch. This safety record, unmatched in any comparable field, is the result of the comprehensive safety management program employed at U.S. national ranges. This program combines the safety expertise and experience of range personnel, the equipment and facilities needed for safe launch operation, and the vehicle safety systems designed to avoid potential hazards. In the course of a Launch Safety Review, DOT will, in general, be attempting to ascertain whether an applicant's launch safety program can assure a level of safety comparable to that achieved at the national ranges.

Launch Safety Review will address the range and vehicle safety resources an applicant has assembled to guarantee that launch operations are conducted safely. Specifically, the review will focus on such factors as:

1. Proposed launch site and flight corridor. Is it possible, under any circumstances, to conduct a safe launch on the proposed azimuth from the location selected? Are there unique environmental considerations associated with the launch site?

2. Range safety expertise. What are the qualifications and experience of the personnel managing and directing the launch safety process?

3. Ground and flight safety process and procedures. What safety procedures will the launch operator use? How are these documented and are they adequate?

4. Range tracking and instrumentation capability. What tracking systems are being used? What is the range of coverage and is it adequate to meet the needs of the proposed launch?

5. Vehicle safety systems (e.g. flight termination). What termination systems design and components will be used? What component and systems tests will be conducted to verify reliability?

6. Proposed vehicle design. Is the vehicle new in concept or untested? Can the applicant's range and proposed safety resources adequately accommodate such vehicle?

Upon receipt of an application, DOT will review the launch proposal in detail to determine whether the safety personnel, systems, procedures and design proposed will effectively protect public safety. During the review, DOT will identify elements of the proposal that may need to be modified in order to secure safety approval.

An applicant's decision concerning the site from which a launch will be conducted can effectively reduce the number of safety issues to be addressed by DOT, thereby shortening the time frame for reviewing and processing a launch application. If an applicant proposes to launch from an established national range, where safety requirements governing equipment, personnel qualifications, and launch procedures developed by the government operator of the range are already in place, DOT's range launch safety requirements will ordinarily be satisfied by a statement of intention to launch from such range. The launch license issued will be conditioned by the requirement that the applicant comply with all applicable safety requirements enable the industry to develop in currently unanticipated ways. Because Federal policy so strongly supports innovative private enterprise in commercial space activities, Federal regulation must be correspondingly responsive to such efforts.

This Notice contains the foundation of the regulatory structure for commercial space launch activities. DOT is currently developing the specific requirements that will be integrated with that structure. A number of these regulatory documents will be published shortly, particularly those focusing on areas where launch activity may be imminent or where information useful to the industry can be assembled quickly. These include:

- *Launch License Regulation.* This document will both reflect and particularize the licensing process set out in this Notice. Specifically, it will outline the regulatory requirements and application process for commercial launches. In addition, it will address such issues as inspection, verification, enforcement, and the terms of the license itself;
- *Insurance Regulation.* This document will provide guidance on the Department's role in establishing third party liability insurance requirements.
- *National Range Use.* Federal policy encourages private launch operators to use the national ranges. This information document will describe the various national range facilities, the types of launch support services they provide and their availability. It will provide guidance to potential users on how to gain access to the ranges, the general costs of service and special requirements of the respective ranges.

Within the time period specified by the Act, the Department will promulgate at least interim guidance, if not final regulations, in each of the areas of commercial space transportation licensing for which the Secretary has responsibility. It is recognized, however, that because certain of these areas represent uncharted waters in terms of both Government and industry experience, issuance of final regulations in such areas can not responsibly be achieved within 180 days. This is especially true with respect to the licensing of private commercial launch sites, an aspect of the commercial space launch industry not presently in existence.

DOT has made no *a priori* determination that procedures developed and utilized at national ranges should be transferred in their totality to private launch sites. In developing regulations applicable to these and all other areas, however, the Department is required to evaluate regulatory alternatives and to assess the impact, costs and benefits of each alternative. This evaluation process with respect to commercial launch sites is now under way. Once the alternatives have been evaluated, DOT is required to initiate the technical analysis and research needed to support the ultimate development of specific regulatory requirements and standards. The need to comply with these procedural requirements for issuance of regulations, however, will not prevent the Department from meeting—within the time period specified in the Act—its equally important obligation to Congress and to the commercial transportation industry to issue general policy guidance on its approach to regulating commercial launch sites.

[FR Doc. 85-[illegible] Filed 3-22-85; 8:45 am]

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U.S. Department of Transportation
Office of the Secretary of Transportation

400 Seventh St., S.W.
Washington, D.C. 20590

JENNIFER LYNN DORN
DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION
U.S. DEPARTMENT OF TRANSPORTATION

Secretary of Transportation Elizabeth Hanford Dole appointed Jennifer (Jenna) Dorn as Director of DOT's Office of Commercial Space Transportation on February 24, 1984, making the announcement after President Reagan signed an Executive Order designating the Department as the lead Federal Agency in the development of expendable launch space vehicles as commercial business.

Ms. Dorn, 33, served as Acting Director of the Office of Commercial Space Transportation during the planning stages for the ELV program.

Prior to being appointed to her new position, she had served as a Special Assistant to the Secretary.

A graduate of Oregon State University with a Bachelor's Degree in Journalism. She also holds a Master's Degree in Public Administration from the University of Connecticut.

She came to DOT from a position as a professional staff member of the U.S. Senate Appropriations Committee, and before that was legislative assistant to Senator Mark O. Hatfield (R-Oregon).

A native of Corvallis, Ms. Dorn is the daughter of Harold and Ethel Dorn of the city.

Mr. **Nelson**. Thank you very much.

I have your budget document dated February 20, 1985. But we don't have any actual request for appropriations for fiscal 1986. Can you give us that?

Ms. **Dorn**. Yes, Mr. Chairman. We would be happy to provide the specific details for the record. But just in general I could lay out our budget and staffing pattern. We are, as you know, housed within the Office of the Secretary, so that gives us a great amount of discretion in terms of using the resources that are also available to other parts of the Office of the Secretary, our policy office, our general counsel's office.

We have a level of effort of approximately 16 professional and clerical people who work on the efforts of the Office of Commercial Space Transportation. We have a ceiling, however, of those individuals who are specifically housed in the office, of 11. Our budget is $583,000 proposed for fiscal year 1986. And added to that sum would be approximately $250,000 available to us for contract support.

We have found that, in order to retain the flexibility of responding to potential needs of the industry without always knowing what those needs are, by having that amount available in not full-time personnel but outside contractors, can be of great assistance to us.

Mr. **Nelson**. Well, we need a request from you for authorization. As you know, for fiscal year 1985, the operation that set up your shop, you were authorized $4 million.

Ms. **Dorn**. That's correct.

Mr. **Nelson**. In section 24. And as of yet, we don't have a request from you on authorization for appropriations. So we're going to need that because we're getting ready to mark up shortly.

Ms. **Dorn**. Fine. We'd be happy to provide that.

Mr. **Nelson**. All right. Do that as quick as you can.

Ms. **Dorn**. Certainly.

Mr. **Nelson**. You said about $583,000. Your budget document shows $586,000. So give us that specific figure, because we're getting ready to roll with this.

Ms. **Dorn**. Absolutely. We should be able to provide that within 24 hours, Mr. Chairman.

Mr. **Nelson**. OK. Good.

[The information follows:]

Commercial Space Transportation (S-50)
Salaries and Expenses

	People		Dollars ($000)				
				Office Costs			
FY 1985	Auth. Pos.	FTE Empl.	Centralized Salaries	OT	Travel	Contracts	Total Cost
Regular S&E Approp.	12	16	491	8	86	48	633
Pay Supp. 3/4-yr.	---	---	+19	---	---	---	+19
FY 1985 Total	12	16	$510	$8	$86	$48	$652
FY 1986							
Adjustments to FY 1985 Appropriation	-1	-1	-43	---	---	---	-43
Subtotal (Adj. Base)	11	15	$467	$8	$86	$48	$609
Annualize Pay Raise 1/4	---	---	+5	---	---	---	+5
5% Pay Reduction 3/4	---	---	-28	---	---	---	-28
FY 1986 Total	11	15	$444	$8	$86	$48	$586

Mr. Nelson. Any other questions?

[No response.]

All right. I made it by 1 o'clock.

Ms. Dorn. Thank you very much., Mr. Chairman.

Mr. Nelson. I made it by 21 minutes, as a matter of fact.

Ms. Dorn. I am available until 1:30. I would be happy to answer questions, if you wish.

Mr. Nelson. Well, let's see, what can we talk about?

Ms. Dorn. That's fine. [Laughter.]

Mr. Nelson. All right. Have a good day.

Ms. Dorn. Thank you.

Mr. Nelson. Now, let's see, I don't know when to tell everybody that we're going to reconvene, because they just threw us a curve today and said that the House is not going to be in session next week.

We are going to recess subject to the call of the Chair.

Thank you. Have a good day.

[Whereupon, at 12:40 p.m., the subcommittee was adjourned, to reconvene at the call of the Chair.]

1986 NASA AUTHORIZATION

TUESDAY, MARCH 26, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met, pursuant to call, at 2:10 p.m., in room 2318, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. **Nelson**. The committee will come to order.

Good afternoon. Last fall, the Office of Technology Assessment released a study on the validity of the space station proposal. This study was in response to a request of the Senate Committee on Commerce, Science, and Transportation, the House Budget Committee, the Senate Appropriations Committee, and our Committee on Science and Technology.

When I read OTA's results in the newspapers last November, I was rather interested in their conclusions. So we are going to have those conclusions explained to us today.

Our first witness will be Mr. Tom Rogers, who was the Project Director of the study, and the study is called "Civilian Space Stations and the U.S. Future in Space."

Since our subcommittee has concurred in the NASA request of $230 million for the space station, I will be most anxious to hear from the Office of Technology Assessment, as well as the panel that will follow, about their technical conclusions. It is going to be important information to have before our subcommittee and before the full committee markup, which will be this week, on the NASA budget.

Now, the expert panel will be composed of Dr. Russell Drew, from the Institute of Electrical and Electronics Engineers, Inc.; also, Mr. John McLucas, from the American Institute of Aeronautics and Astronautics; Mr. John Robinson, from the American Society of Mechanical Engineers; Mr. Ben Bova, who will be accompanied by Dr. Glen Wilson, of the National Space Institute.

Our panel will not only address the findings of OTA, but each person will also give us his association's reaction to the NASA budget proposals for the upcoming fiscal year.

Then we are asking Congressman Ed Zschau of California to come in and share with us from his technical and scientific background as to his conclusions as to the NASA budget, the space station. He was a director of the American Electronics Association before becoming a Member of Congress. He has been interested in one of the NASA science projects, Gravity Probe-B, which is an experiment to test Einstein's theory of relativity, and we, in passing out of this committee, the NASA budget, have included an item of $9 million in that budget for further research on Gravity Probe-B.

Now, Mr. Rogers, we're looking forward to having you speak to us and I want to turn to my ranking member of this committee, Mr. Bob Walker, for his comments.

[The prepared opening statement of Mr. Nelson follows:]

OPENING STATEMENT
HON. BILL NELSON

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
HEARING TO REVIEW THE FY 1986 NASA BUDGET REQUEST

March 26, 1985

Last fall, the Office of Technology Assessment released a study on the validity of the Space Station proposal. This study was in response to a request of the Senate Committee on Commerce, Science and Transportation, the House Budget Committee, the Senate Appropriations Committee and our own Committe on Science and Technology.

I must admit that when I read of OTA's results in the newspapers last November, I was rather startled at their conclusions.

Our first witness will be Dr. Tom Rogers, who was the project director of the study -- Civilian Space Stations and the U.S. Future in Space. Since our Subcommittee has since concurred with the NASA request of $230 million for the Space Station program next year, I will be most anxious to hear from the Office of Technology Assessment as well as from the panel of representatives from technical associations which will follow. This will be important input before the full committee markup on the NASA budget tomorrow.

Our expert panel will be composed of: Dr. Russell C. Drew from the Institute of Electrical and Electronics Engineers, Inc.; Mr. John L. McLucas from the American Institute for Aeronautics and Astronautics; Mr. John W. Robinson from the American Society of Mechanical Engineers; and Mr. Ben Bova who will be accompanied by Dr. Glen P. Wilson of the National Space Institute.

Our panel will not only address the findings of OTA, but each person will also give us his association's reaction to the NASA budget proposals for the upcoming fiscal year.

The final witness of the afternoon will be Congressman Ed Zschau (R-California). The Congressman has had a strong technical and scientific background before becoming a member of the House of Representatives. He was the founder and president of his own company -- Systems Industries, Inc., and in addition, he was a director of the American Electronics Association. Congressman Zschau has been interested in one of the more exciting physics projects that NASA has undertaken -- Gravity Probe-B -- which is testing a number of Einstein's theories of relativity. I am also looking forward to his thoughts on the Shuttle pricing concept that this Subcommittee agreed to last week.

We will get on with Mr. Rogers, our first witness, as soon as we hear from our Senior Republican Member, Mr. Walker, with his opening statement.

Mr. **Walker**. Thank you, Mr. Chairman. I agree with you, our hearing this afternoon should prove most interesting, particularly since our lead-off witness is from the Office of Technology Assessment that released the study on the role of NASA, its future missions and particularly the role of the space station in our space future.

As I recall, the Washington Post characterized the OT—OTA study as saying that space station is unjustified on scientific, economic or military grounds. I don't believe that that harsh judgment will be supported by either the OTA study or by the facts when we look at it in more depth. I hope that OTA will clarify their position on this here this afternoon.

This subcommittee is strongly committed to a manned future in space and we see the space station as man's next logical step. I also strongly support the concept of private sector capital investment in this station. I welcome OTA's support of that concept that appeared in their study.

One of the issues we have yet to resolve is how to best create a broad base of public support for the next generation of space activities. We all remember how President John F. Kennedy galvanized an entire generation when he challenged America to accomplish the goal of sending man to the Moon and returning him to Earth within a decade.

Now, a quarter of a century later, we have new challenges and we need new catalysts and we need to proceed ahead with those new catalysts. Within a few days, one of the major TV networks will show a miniseries based upon James Michener's epic novel "Space."

I think that this series may help recapture American imagination and may help build upon a growing interest among Americans about building the new technology that will again begin to carry us beyond the bounds of Earth and it is in that kind of context that I welcome the testimony here today, Mr. Chairman.

Mr. **Nelson**. Thank you, Mr. Walker.

Mr. Rogers.

STATEMENT OF THOMAS F. ROGERS, PROJECT DIRECTOR, CIVILIAN SPACE STATIONS ASSESSMENT, OFFICE OF TECHNOLOGY ASSESSMENT, U.S. CONGRESS, ACCOMPANIED BY JOHN ANDELIN, ASSISTANT DIRECTOR, OFFICE OF TECHNOLOGY ASSESSMENT

Mr. **Rogers**. Mr. Nelson, Mr. Walker, Mr. Smith, you should know that I appear here——

Mr. **Nelson**. You need to turn on that microphone, Mr. Rogers.

Mr. **Rogers**. Well, space-based technology is not nearly the problem as surface-based technology.

I am here in my capacity as the Director of the OTA study, but you should know that I did that work as a consultant to the Office. I am not a member of the Government or OTA, but I am accompanied by my professional colleague, the—one of the assistant directors at OTA, John Andelin.

I would say two things at the outset. First, we found in our study that it wasn't very useful to use the term "space station." We found it to be a too-rigid, a too-sharply focused and not a very instructive expression for what we were dealing with and what you are dealing with when you talk about space station. After some considerable thought and discussion, we adopted a very well-known expression in the engineering and the construction world, infrastructure, space infrastructure.

What we are talking about under the general rubric of space station are the emplacement of methods and means for the support of other space assets, but primarily space activities which are ends in themselves. The infrastructure, except in institutional terms, perhaps, is not an end in itself; it is methods and means whereby people and equipments can see things done as ends.

The second thing I would say is that there has been an element of semantic confusion about the expression "space station," and it's this: We hear the expression "the" space station, "the" space station. There is no such thing as "the" space station in our view. There is an array, at first conceptually, then analytically, then in development, then in production, installment and use, of space infrastructure elements. These elements are elements in which people can reside, in which people can function. They will have electricity; they will have communications; they will have life support systems.

"The" space station is taken as the description of the specific 2-year-ago NASA aspiration. That aspiration has changed in some detail in that period of time. It's undergoing further study by NASA and the space industry today and in the universities, and it will continue to change. The President did not use the expression "the" space station; he said "a" space station within a decade, and that's as we understand the expression.

So it would be helpful to distinguish in the discussions and in our minds and analyses between "a" space station, that is, an array of infrastructure elements designed to support space activities and "the" space station, which might be at any one time the specific characterization of these elements by the administration when it asks for authorization and appropriations to proceed.

Now, against those two general remarks in background, I would stress the following, in the light of the reference to the Washington Post. The Washington Post article used the word "the." The OTA reports says that OTA is convinced, without qualification, that we should have what we would call a space station, without qualification. We say that there are certain things that need, in low-Earth orbit, infrastructure elements if they are to be done; if they are to be done well; if they are to be done, in some cases, at all. And we think that it is in the interest of the country to see that those infrastructure elements are obtained and obtained soundly and smartly.

We say that—that the country should be pursuing activities in the life sciences and that requires people up there, both to conduct experiments and to be experimental subjects, for long, long periods of time. We say that you should—the country should be conducting experiments in the materials sciences area, and that requires that the experiments there be conducted over long, long periods of time. And we also suggest that learning how to develop automata and robotics in space, for use in space and for applications at the surface, requires that we have infrastructure for long, long periods of time.

And we are also convinced that we have reached the point where it is important to learn how to deploy low-Earth orbit and higher orbit infrastructure elements to service spacecraft in orbit.

Now, I would like to stress this because there has been confusion about that. Our report says that a sound case has been made for doing these things and for obtaining the infrastructure to see that, in fact, they are done, done well, done effectively and done efficiently.

The rub comes when we equate that to the expression "the" space station, because what we have just said, we are convinced the country should have, is short of what NASA describes in its aspirations for "the" space station. We would go on to say that while there are other things that one can rationally advance in justifying further infrastructure elements than that, we are not persuaded, on balance, either that the uses to which it would be put are sufficiently crisply known, confidently put forth, and accepted by the Congress. And we would also suggest that there are other things than infrastructure that should be taking the attention, the funds of many of our seniors in the civilian space program.

Let me give you two examples. There is the argument advanced, rationally, that one can, in low-Earth orbit, with the proper kinds of people, tools, storage capacity and so on, assemble very, very large structures. As a general argument, that makes sense.

On page 2, you would ask the question: What large structures? To do what? For whom? Who would purchase them? Who would use them? What large structures? And until the administration comes forth and says to the Congress that they have some reasonably specific large structure, real large structure objectives in mind—and by the way, there can be—we think that one would be just a bit cautious in saying that you need upfront, soon, large infrastructure elements to support the activities of large space structure assemblies and tests and checkups; not that it doesn't make, in general, sense to do that, but we point out that—that there are other things that you could pay attention to and unless convinced that this makes a clear, important and present case, might want to set it aside and look at some other things before rendering a judgment.

Another example often stated or justification advanced for a large and sophisticated space infrastructure is that it could be used as a base for further human exploration of the solar system. Now, as a general proposition, one can't quarrel with that at all. We don't. We simply say that nobody is vocal about that in the administration. Nobody has stood forward and said to the Congress, to our knowledge, that the country perforce should be committed to seeing human exploration of the solar system and that it would follow that the way to do this efficiently and soon is to have the proper kind of in-space infrastructure.

What we are saying is, in brief, that some of the arguments made for the—for in-space, long-term, indeed, permanent infrastructure do bear up as the sorts of things that have been discussed, have been studied, for which there is general or, rather, clear and immediate agreement, other things not so clear.

So the question remains, in our view, that of the Congress deciding how much infrastructure, of what general kind is needed by when, and what should the public first be expected to pay for it.

The NASA Administrator said something that is absolutely correct and extraordinarily useful in testimony before the Congress several years ago in speaking about space station. He said, "You can buy it by the yard." You can buy it by the yard. Unlike an aircraft development, which once you commit yourself to it, you then are—it's incumbent upon you to see that it has wheels or sleds or you'll regret it, and enough engines or you'll regret it.

In the case of infrastructure, there is no such objective quantitative need. How many inhabitable modules do we need by when? NASA says five. One could make the case for six; one could make the case for four. Six costs more than four. When do you need the five? How much power do you need there? NASA would say in "the" space station aspiration, 100 kilowatts. Well, 50 would get you in the position to do a great many things; 200 much more. There is nothing particularly magic about either five modules or 100 kilowatts, so the question before the Congress is then, in the light of all the other things on your plate and all of the other things demanding your attention and public funds, how much infrastructure—and we agree there should be some—how much of what kind is required to do what that we have agreed we should do by when?

Now, we should also distinguish between cost and payment of cost. In all of the discussion until quite recently about space station, it was taken for granted that all of the funds would be Federal taxpayer-derived funds. We would observe two things: One, we are all in favor—at least to some extent—of international cooperation in space. The administration has done well in describing our activities in space station terms and in encouraging cooperation with other countries.

These countries have expressed themselves as being willing to spend some $2 to $3 billion in the general space station area. We think the question should be raised as to whether or not these moneys should be added to what the public, the American public is expected to pay, or whether they should be subtracted from what the American public should be asked to pay.

We may not have a clear sense as to the answer to that question, but under today's circumstances we suggest that the Congress should ask the question.

Second, we would say that the time seems to have come when the space industry, in being and coming into being, should now not only be allowed, but be encouraged, indeed, prompted, to put private capital and put private endeavor to good use and to risk by developing some parts and producing some parts of this infrastructure and offering it at what we would hope to be lower cost to the Federal Government on a purchase or lease or rental basis of some kind. We think that the time has been reached when that is a fair question to ask an industry that began to be created a generation ago.

Since the issuance of the OTA report, the administration has made two very fine, in our judgment, suggestions. Phillip Culbertson's testimony of just a short while ago has him saying to you that

NASA will be prepared to come back and present you with options for space station cost levels and things to be attained at the various cost levels, some more than $8 billion; some less than $8 billion. We think that is a sound thing to do; we think that is a fine thing to do; we think that should be encouraged.

The second thing is that—is that Mr. Culbertson also said—and while I'm not quoting directly, it's to the extent that there—the sense that there now can be a role for the private sector in building elements of space station with private capital, and that it, NASA, will try to understand how to prompt such a development. We think that is fine; we think it should be encouraged.

Now, having said all that about space station, we would say one more general thing, and that is that it is very difficult to form useful judgments about the character and the magnitude and the utility of space station absent a clear and an articulated and an agreed-upon new generational agenda for the civilian space activities of the United States, particularly the public space activities of the United States.

It is an extremely difficult thing—in fact, I think it sometimes borders on the impossible—to ask thoughtful, responsible experienced engineers to design infrastructure costing a great deal of money, taking a great deal of talent and taking a great deal of time to produce, without a clear articulation of the things to which it is to be put.

We have said in science we can understand it, and in support of satellites, for servicing, we can understand it, but there are so many more things that this country could be doing in the space area. Large things, exciting things, attention-taking things, useful things; that in addition to spending time and assets and energies on the development of more infrastructure should also be taking the time and the attention and the energies of these engineers. But absent a refreshed and a rearticulated set of goals, national goals, and specific objectives to address those goals, it is a very difficult task that we lay by implication on those engineers to imagine what those things someday may be and to design the roadway and the telephone system and the gasoline stations and the storage bins to support it.

Let me draw your attention to the stark contrast between the debate now under way in this country on military activities in space in the strategic defense initiative area alone—let me draw the stark contrast between that debate and that amount of attention and the debate and attention being received by the civilian elements of our space activities and programs.

We still await the declaration by the administration of the membership of the National Commission on Space. We look forward to that. The Congress initiated that; the President agreed to it; we badly need it; we hope that it will be on line soon.

I would conclude by making two final observations, Mr. Chairman, and gentlemen. One is that it may very well be, in view of the great time that it's taken to put together the presidential commission, that if it doesn't come into being soon enough to meet your purposes that you could think of seeing your own studies started because we certainly need them.

And second, I would say that throughout all the time that I spent with OTA on this study, while I was left with many impressions, there is one that has made the most impression of all on me and that is that there is nobody, essentially nobody in this country, performing formally informed professional policy-related studies in the civilian space area. There may be a few individuals, an historian here or there or a consulting group that would call itself a policy-related activity, but outside of the Federal Government, there is no place that you can go to in this country and find thoughtful, experienced, objective analyses being conducted of civilian space policy issues. That is sorely needed and if the Congress could prompt those coming into being, it would be a definite help.

I'd be prepared to do my best in answering your questions. Thank you.

[The prepared statement of Mr. Rogers follows:]

STATEMENT OF MR. T.F. ROGERS

Project Director
Civilian Space Stations Assessment
Accompanied by John Andelin
Assistant Director
Office of Technology Assessment

Before the House Committee on
Science and Technology
Subcommittee on Space Science and Applications

CIVILIAN "SPACE STATION"

March 26, 1985

Mr. Chairman, I am pleased to appear before you today to present OTA's comments on a U.S. civilian "space station." As you know, the OTA report on Civilian Space Stations and the U.S. Future in Space was published last November. Rather than simply summarize the report's findings, I will comment on how those findings apply to developments since publication.

First of all, I want to make it clear that OTA remains convinced that there is a strong rationale for some long-term, habitable infrastructure in low Earth orbit (LEO). (By "infrastructure," OTA refers to the range of space-related facilities and services that would support routine, operational activities in space.) In other words, OTA is very positive about the principle behind the President's call for a "space station" and the Congress's decision to fund a "space station" line item in NASA's budget.

Second, OTA emphasizes that U.S. civilian space capabilities are now so strong, and scientific and engineering knowledge so developed, as to allow this Nation to undertake, with the expectation of a successful outcome, any space activity it could reasonably desire.

Third, OTA cannot emphasize too strongly that the element currently lacking in the U.S. civilian space effort is not any form of scientific or technological know-how or funds, but a national agenda of goals and objectives. This agenda should no longer be set solely by members of the traditional "space club," but through a much broader discussion, that draws upon the knowledge and views of Americans in many fields and with differing points of view.

Fourth, OTA continues to be concerned with the great difficulty that the government experiences in reducing the unit cost of space technology and activities, and in seeing that our private sector provides more of its own resources to the development of space.

In accordance with these four findings, the OTA report suggested some possible national goals and objectives. These goals were provided to give a sense of the range of possibilities open to us, and to make clear that various technological approaches are appropriate for various goals. However, OTA remains seriously concerned regarding some characteristics of the particular "space station" program NASA now envisions. Some readers of the OTA report have expressed the opinion that it is contradictory for OTA to suggest ambitious and costly goals and objectives, and yet to hold reservations about NASA's space station program. Let me try to clarify this matter.

Cost, Cost Sharing, and Public Cost. It has become clear that NASA does not regard the $8 billion estimate of the cost to develop an "initial operating capability (IOC) space station" as a total cost; we are even more convinced than we were six months ago that this estimate is a floor rather than a ceiling. One addition to this estimate will be some $1.1 - 1.7 billion (1985) (depending on how the capital and operating costs for Shuttle flights are calculated[1]) to pay for the (estimated) 7 Shuttle flights dedicated to transporting "space station" hardware and technicians into LEO.

Potential international partners may be willing to contribute as much as $3 billion toward the construction of international space infrastructure. Unfortunately, in our judgment, NASA has made it clear that such monies would be added to the total available for building a "space station," not subtracted from the amount otherwise required from the U.S. public purse. In today's budget circumstances, we suggest that the Congress could reassure itself as to whether or not the present position indeed is the better one.

There are, however, three particularly hopeful signs. One is that NASA has begun to look with favor on the possibility that the U.S. private sector may participate in the "space station" program, at least to some extent, as providers as well as users. In testimony last month before this Subcommittee, Phillip Culbertson, NASA Associate Administrator for Space Station, said, "we believe there can be a role for the private sector in building, with private capital, elements of the space station. We plan to better understand what might be done to encourage such commercial participation." This possibility, in OTA's view, is one of the keys to reducing the cost of space assets and operations, both in absolute amount over the long term and even in public funding required for the first generation of space infrastructure. We can only trust that NASA will soon move to publicize its willingness to purchase or lease portions of the infrastructure that would meet its performance needs and costs directly from private commercial and industrial sources.

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[1] See "The Costs of the Shuttle" and "Pricing Options for the Space Shuttle," Chapters II and III of Pricing Options for the Space Shuttle, Congressional Budget Office, Congress of the United States, March 1985, pp. 11-30.

Second, as Mr. Culbertson also noted, NASA's Phase B definition effort will be considering the human-tended approach and the automation/robotics approach as genuine alternatives to some portions of the "all-up," human-resident approach. If these approaches are indeed taken seriously, there is a good possibility that they will suggest substantial public cost saving measures.

Third, the planning effort for the "space station" program is much more thorough and extensive than what has been characteristic of previous large NASA programs. Such an effort increases the likelihood that the entire program will be free from costly "surprises." In this connection, NASA's decision, as reported by Mr. Culbertson, to examine alternative "space station" options, some costing less, some more than the canonical $8 billion, is to be commended.

And there remains another area where substantial public cost saving could be effected. NASA could develop the orbital maneuvering vehicle (OMV) and any reusable orbital transfer vehicle (ROTV) in close concert with those in the private sector who look forward to using them to provide satellite support services. In that case, the government could probably acquire these vehicles at a lower cost, and, equally important, the private provision of such services would be speeded. Of course, any ROTV should be developed in such a fashion as to take the maximum advantage of other "space station" technology developments, and be able to serve not only assets and activities in higher and in geosynchronous orbits but in lunar orbit as well, should this be needed.

An Alternative Direction for NASA. In the past, it has been NASA's responsibility to meet any given national civilian space objective by itself; in the future, it should be NASA's responsibility to see that the Nation's long-term objectives are met. Today, the rapid increase in foreign and commercial activities means that other government agencies now play a greater role in space. Already, the Departments of Agriculture, Commerce, Interior, and State, and the FCC, in conjunction with the private sector, manage most of the civilian applications of space technology. Recently, the Department of Transportation was charged with promoting and regulating private sector space transportation systems. In today's dynamic environment, what is the appropriate role for NASA, the Nation's premier space R&D agency? The answer, we think, is twofold: first, to manage an orderly and early transition to the private sector of activities which can proceed with in-hand technology; second, to turn the bulk of its attention to longer-range challenges and possibilities.

Mr. Chairman, permanent in-orbit infrastructure presages a new era in the considered development of space. Like development of a parcel of raw land on Earth, space development will be increasingly driven by market forces. It is important therefore that the initial government commitment to this process — in this case, a major portion of the "space station" infrastructure — be aimed at maximizing the potential of private-sector and other users of the facilities.

Thus, the "space station" program must be appreciated for what it is: a means, not an end in itself. To be more certain that the facilities actually constructed are the ones most likely to lead to optimum space development, they must be constructed with an eye to the Nation's long-range civilian space goals and objectives. Unfortunately, the only space goals discussed to date are those forumulated by the space community itself:

there has been little broad-based discussion and agreement on a set of long-range goals for the United States. I draw your attention to the stark contrast between the current vigorous public debate concerning the military space strategic defense initiative and the barely detectable discussion of our civilian space aspirations. In OTA's view, the National Commission on Space — which was included by this Committee in last year's authorization legislation — represents a crucial opportunity to initiate and broaden public discussion of this matter. Further, we suggest that, in parallel with NASA's Phase B engineering studies for the space station, the Congress seek independent studies suggesting goals and specific objectives for the Nation's future activities in space, studies conducted primarily by people outside the space community. In that way, the final design choices could be made with a much better view of how they could serve the Nation's long-term future.

OTA also suggests that attention be paid to the possibility that new procurement strategies more appropriate to the era of space commercialization should now be adopted. In essence, the alternative strategies would require that, in producing other than "cutting-edge" technologies, contractors work to performance specifications, rather than to detailed engineering specifications (as they do now). This approach would signal that the U.S. space industry is maturing and is no longer in need of detailed NASA supervision over all of its engineering and production activities. This approach would also free NASA to develop the higher risk technologies and programs that we cannot expect private industry to support. This division of effort, where private industry works on projects that can be reasonably expected to be profitable and government on those that are in the longer-term interest of the Nation, is the typical U.S. approach in most, if not all, commercial-industrial activities in which government has a role. Such a division of effort in space activities, with a view to its full implementation over the next quarter century, should begin with the civilian "space station" program.

Released from its present relatively near-term focus, NASA could concentrate more of its professional activities on the most important and exciting options in and concerning space, the things that no one else can or will do: the very best of space-related science; the cutting edge of space-related technology development; the boldest of space-related explorations.

The Long-Term Future of the Civilian Space Program. Since the passage of the National Aeronautics and Space Act of 1958, the existence of separate military and civilian space programs have served the Nation well. There is no reason to suppose that such a separation would work less well in the future. If, however, the United States undertakes a very large space-based missile defense R&D program along the lines of that called for in the President's Strategic Defense Initiative (SDI), thought must be given to the important side effects this would have on the civilian space program. That is, the development of a full-fledged SDI program would require such a large effort, and capture such great national and international attention, that the importance of a separate civilian program might well be forgotten, and the United States could be judged as having placed undue emphasis on military space development and use. Our report has outlined several civilian activities which, if undertaken with purpose and elan, could yield social, political, and economic benefits, would capture public attention, and would be in our national-security interest to pursue. Under these circumstances, the Congress may wish to express its intent that some significant portion of the national effort in space will continue to be directed toward important civilian ends.

It is true that a "space station" such as NASA currently envisions would stake an important civilian claim in the space domain. In OTA's view, however, there may be better ways to do so:

1) NASA could ensure that the space infrastructure is developed in a truly collaborative, cost-sharing way with other space-faring friendly countries;

2) NASA could also seek more, and more independent, private-sector provision of infrastructure elements;

3) the United States could move to debate and then articulate a contemporary set of broad and enduring civilian space goals and specific program objectives; and,

4) NASA could then proceed to use those financial and professional resources husbanded in the "space station" area to address these important national ends as well.

Congressional Options. As OTA has said on previous occasions, there is no such thing as "the space station." Rather there are various ensembles of infrastructure elements, the choice among which should be made with clear appreciation of the goals and objectives they are intended to serve. It is this central fact which assures the Congress that significant choices remain to be made in its support for any "space station" program.

The Congress and the general public should not find themselves in the position of having to decide on large, complex, and very costly items of space infrastructure such as the proposed "space station" without having a much clearer understanding of what these items will be used for over the long term, and without being confident that their character, the uses to which they will be put, how they are to be acquired, owned, operated, and paid for, have all been carefully considered and conclusions reached that reflect our broadest national interests.

Options for Acquiring Space Infrastructure

o The Congress could simply agree to provide the kind and number of in-space assets and services that NASA judges to be necessary and, accepting its $8 billion cost and 7-8 year schedule estimates as working numbers, be prepared to approve the acquisition of the general kind of infrastructure elements that the NASA Phase B studies recommend.

- o The Congress could specifically identify any major space services to be provided, ask NASA to present, in the light of the results of the Phase B studies, various estimates of costs, schedules, and procurement strategies involved in providing them and, subsequently, select from these estimates the elements and strategies to be approved.
- o The Congress could set an average annual funding rate and allow NASA to choose the infrastructure elements, acquisition schedules, and procurement strategies that it judges best suited to realize the aims of the "space station" program. The OTA report provides estimates of what kinds of infrastructure elements could be provided, when, at four different funding rates.

Options for Coordinating Infrastructure Acquisition with Goals and Objectives

- o The Congress could authorize one or more short-term studies suggesting goals and specific objectives for the Nation's future activities in space. These studies would be most usefully conducted by people outside the space business and should be completed in time for comparison with the results of NASA's Phase B engineering studies.
- o The Congress could consider prompting the establishment of one or more modestly sized, policy-related study centers outside of the government. Provided with sufficiently broad charters, and funded so as to assure both independence in, and long-term support of, truly challenging studies, professionals would be attracted to conduct the kinds of broad inquiry and analysis that the civilian space area now so badly needs.
- o The Congress could urge the early activation of the National Commission on Space, called for in Public Law 98-361.

Mr. **Nelson**. Thank you, Mr. Rogers.

I agree with you about the Commission on Space and think that that will be very helpful to all of us. You might be interested to know that when we marked up the bill last week, that we extended the life of the Commission for another 6 months so that they will have a chance, assuming they are to be appointed very shortly, that they will have a chance to work their will, as we hope that they will, and give us the feedback.

Now, I want to understand, Mr. Rogers, the context in which you come to us today. The Office of Technology Assessment was set up by the Congress to advise the Congress, is that correct?

Mr. **Rogers**. That's correct. Excuse me. I withdraw that.

Mr. **Andelin**. I think the word "advise" is the one that we would quibble with. We are an analytical arm. Our job is to understand what we can of the technology, the issues surrounding them, the relationship between them. We will make findings and draw conclusions. In general, advice is something that we believe to have enough value judgment to leave to Members of Congress themselves. So we're nervous about being described as one that gives advice.

Mr. **Nelson**. All right, I understand that, and thank you for clarifying that. And you perform a valuable function for the Congress in that role as analyst. Therefore, I would wonder about your statement in your opening comments where you had stated your opinion that NASA had not put forth the concept of the space station "crisply," was the word that you used. Then you went on to make a very interesting statement and that was: "nor has it been accepted by the Congress." Now, how is it your role as analyst of technical matter to advise us as to whether or not the Congress has or has not accepted a certain policy?

Mr. **Rogers**. We're not talking about policy, Mr. Nelson, not at all. We agree—and had prior to the findings of the House and Senate—that a case could very clearly be made for permanent infrastructure; that it could be obtained within a decade; that it would be useful to have and we should have it, so there is no quarrel about that whatsoever.

We went on to point out, though, that the administration advanced something like 100 uses for a space infrastructure and of all the ones that we could study, and we did, and had others study with and for us, only a relative handful, important, very important, but only a relative handful stood the test of do you need permanency? Do you need people? Do you need it soon? Is it clear that the country is moving in that direction?

And I gave you examples of some of the things that are advanced as reasons or were advanced as justifications for having infrastructure, but which you don't see advanced by the administration.

I gave the example of assembling very, very large and sophisticated structures. Now, as a general—as a generality, one cannot quarrel with that, but if you ask—give us an example, what kind? Is it a radar? Is it for communications? Is it for remote sensing? What?

You can't find an answer to that, and this is what struck us as being, in a sense, almost backward about the explanation or the justification for some of the infrastructure. Now——

Mr. **Nelson**. Mr. Rogers, let me stop you there. You are going astray from my question. I understand what you said and it is a part of the record and we appreciate that. I want to understand our appropriate roles here when you are commenting on what has and has not been accepted by the Congress.

Now, where in your charter is—or what evidence do you see that you—that you are to state to us in a technical analysis that the Congress has or has not accepted certain of these things of which you are critiquing?

Mr. **Rogers**. We read the record, Mr. Nelson. The Congressional Record. I don't know of any piece of paper that says that Congress has taken the position that we ought to have human exploration of the Moon. Now, that may be a fine thing to do and NASA may want to do that, but we don't see that that has received any critical level of study, let alone affirmation, on the part of the Congress.

Mr. **Nelson**. Now, how did you—I'm confused. How did you suddenly jump back to the Apollo Program, manned exploration of the Moon, in speaking of the space station?

Mr. **Rogers**. No, there are—one of the justifications advanced for having infrastructure elements in low-Earth orbit is that——

Mr. **Nelson**. All right, I understand that.

Mr. **Rogers**. OK.

Mr. **Nelson**. Well, let—let me just share with you that the fact is that what is or is not accepted by the Congress is a matter of putting votes together and I would—I would think that if you will give us the specifics of your critique, as you have, and stay out of those policy judgments, I think you would be well-advised.

Mr. **Rogers**. It may be we have a semantic difficulty—it may be that I don't quite understand. Let me—if you say what is acceptable to the Congress, then there's no difficulty at all. You can—of course, you can and will deal with what is and is not acceptable to you, but I think I used the word "accepted," those things which you have already acted upon or what you have not acted upon. That's the point I was trying to make.

Mr. **Nelson**. All right, then, that distinction is clear.

Mr. **Rogers**. OK, fine. Thank you.

Mr. **Nelson**. All right, Mr. Walker.

Mr. **Walker**. Thank you, Mr. Chairman.

Let me say I really—I appreciate your clarifying the points of your study. I think that what you told us today is somewhat different than many of the reports that followed after the study and I would just like to spend some time here clarifying some of the points that you made.

Do I understand correctly that you see, after studying, the need for a permanent manned facility in low-Earth orbit?

Mr. **Rogers**. Yes.

Mr. **Walker**. And that, as opposed to a man-tended kind of operation. You see something that would—where you would have people living aboard it for—for long periods of time?

Mr. **Rogers**. Yes. Clearly, you can also do that, but we do see the necessity for—we use the expression, "long, long periods of time." Permanent is certainly——

Mr. **Walker**. And, if I understand what you're saying correctly, that—that that permanent presence there should be in a part of an overall policy context of doing something useful over a long period of time, rather than being an end in itself.

Mr. ROGERS. Absolutely. Absolutely.

Mr. WALKER. And—and—and that that's really the clear distinction that you're trying to make is, that that station should not be a policy end, in and of itself; it should be one part of a larger policy. Is that——

Mr. ROGERS. That's correct.

Mr. WALKER. And—and—if I—and I understood you to say that engineers can obviously do this thing; that you can assign them the work of building it, but if they build it without context, it doesn't make much sense. It's a little like going out to a canyon and building a bridge that we know they can build, but there is no road on either end—on either side of it so that the bridge stands out there as a marvel of engineering genius, but—but there's—there's no context for it being there. Is that——

Mr. ROGERS. Yes. I would give the very simple example: power. How much power do you put up there? Ten kilowatts is a lot. Fifty kilowatts is more. A hundred is even more. Two hundred, you know, but it costs $5,000 a watt installed. It's a large amount of money and so, unless you have some very clear and agreed-upon sense of what it is you're going to do, it's asking the impossible of the engineers to say, "You judge how much power we're going to need." It might turn out to be much more than you need or not nearly enough.

Mr. NELSON. OK, so—so, for instance, to use the example that you just used, and there may be one or two more—that if, in fact, there was a national policy agreed upon by Congress, that we were going to move toward manned exploration of the Moon and manned utilization of Moon minerals, that, in fact, would drive a particular kind of design for the space station because, obviously, if you were going to process minerals off the Moon, you would have to have certain kinds of power requirements in space to do that.

Mr. ROGERS. Absolutely correct.

Mr. WALKER. And if—if we were going to build the infrastructure that you talk about, that that infrastructure has various elements that would also drive our decisionmaking, and, for instance, that infrastructure is going to be largely industrial in its context. That also has engineering kinds of decisions to be made. Is that——

Mr. ROGERS. Yes, absolutely.

Mr. WALKER. Now—now given that, have you drawn any conclusions as to what kind of policy is being aimed at? I mean, we now have some plans floating around about what this station should be. You mentioned yourself that it should be five—you know, that it has been decided it should be five modules with 100 watts of power capacity. Have you been able to discern what kind of policy options that particular station is based upon?

Mr. ROGERS. There's one thing I don't want to be understood to be saying, if I may, Mr. Walker, and that is that the people at NASA haven't studied this very, very hard and very, very honestly. They have and they are. They've made the best judgments that they can, and certainly, having these modules and this power and this stability and these numbers of people will enable them to do a great many things.

We live in a very dynamic world, however, and to ask them to predict the future absent the policy statements and absent the Congress finding what is acceptable to the Congress about what you do with all of this infrastructure, I repeat, is asking a very great deal of these men and we may be asking the impossible.

Now, what—what can you do with this much power? You can do a very, very great amount of—of—of materials—material science. You can do things in the life sciences area. You can do—you have the beginnings, particularly if we go on to building a reusable orbital transfer vehicle, you have now the beginnings of an efficiency revolution in the spacecraft area, whereby now we can change them, support them, modify them and not have to write them off or bring them back to the Earth's surface. There are a great many very, very useful things that you can do with that.

So I don't want to be misunderstood as saying that it's too limited.

Mr. WALKER. OK, but—but—if I understand correctly the points that you made—and that in the context of the points that you made—if, for example, we would make a policy decision that the space infrastructure that you spoke about, rather than a space station, should include a habitat which we all agree is—is necessary in space, and then a building of, let's say, a space industrial park around that habitat, that that would certainly bring a different kind of design perhaps than what NASA now has in mind.

Mr. ROGERS. Oh, yes.

Mr. WALKER. Is that right, because——

Mr. ROGERS. Oh, yes.

Mr. WALKER. Because in that kind of context, using some of the elements that you're talking about, you, in fact, would provide a habitat, but any of the laboratories, any of the industries, any of the things that you do might, then, provide their own power structures, might provide a—a different kind of design and therefore, there would be a—a difference in cost and so—so that that, in fact, should be a decision.

We ought to—we ought to know what it is we are trying to do with this initial space station before we settle upon a design. Is that—is that essentially——

Mr. ROGERS. Well, I would—I would say that it's not quite that far, but almost. That is, we think—we judge that they have made a good case for doing some things, but have not made a good case for doing everything that they want to do and that we ought to hold something back in reserve on that judgment.

Mr. WALKER. But I particularly like your point about the fact that private investment ought to be encouraged, that there may be a real role for private investment here and we have already seen private investment suggest that, with the use of leasecraft, they're going to put robotic factories in space.

My own guess is that you create an even better investment climate if you can—if you can fly Leasecraft in close proximity to a space station and then allows that—that leasecraft to be serviced in orbit, and that you can encourage even more investment in the future if you create that—that kind of—kind of a system and that you can encourage more investment if we make appropriate decisions here about—about that investment climate.

But that you—you somewhat change that mix if what you are telling business right now is "We are going to build a space station to which you will plug in in the future." Is there somewhere I'm wrong in my——

Mr. ROGERS. Yes, let me give you an example of—or characterize two ways of going about things that I have experienced in my advisory capacity, before joining OTA, to NASA and the Academies. Sometimes the Government will say, for its own purposes, it wants to design, develop and put some hardware, some technology in space. It usually does a good job of that and the scientists—it is usually for scientific reasons—but the rub comes when they then hope that that technology can be quickly and, with modest additional expenditure, taken over by the industrial-commercial sector and put to good and useful and early economic ends. It almost invariably turns out not to be the case.

Now, in the communications area at NASA, they have learned not to do that. To the contrary, as they develop their satellite research and development program, their satellite communications programs, they bring in industry and they ask them what they believe, in their judgment, the government should be trying to do to help them, to prompt them, and they work out a cooperation arrangement in which both sides put things in and both sides get things out.

Now, I think that in the matter of the space structure—the space infrastructure area—there are things which, in the longer term, would turn out to be our economic advantage if the industrial people were to work with NASA to say, "Well, if you want"—take the matter of the reusable orbital transfer vehicle. Supposing that we decided that that had great possible economic use. Well, imagining the government, addressing its own research purposes, would design that so that it had the most economically attractive features in it is a most unlikely assumption. But if they were to work closely with the industrial groups and trade off advantages to both the government and the private side for developing certain kinds of technology and certain kinds of operations, I think we'd both be better off.

Mr. WALKER. I'll come back, Mr. Chairman. Some others are here.

Mr. NELSON. Mr. Smith and then Mr. Volkmer.

Mr. SMITH. Mr. Rogers, pardon me, I have a cold, so if you have a little trouble understanding me—the—your comment about we should be and could be doing, quote, unquote, exciting things in space, that's—that's an interesting remark. I haven't been on the committee very long, but what I've seen and heard in the testimonies since I've been here sounds very exciting to me, space telescope, exploration of Jupiter, Uranus, international solar polar mission, space station itself, to name just a few. These are exciting things.

Can you—in addition to that, the—the—the research that many of the scientists that have testified before this committee in terms of zero gravity and what they could do, medicine and so forth, all of these things are very exciting to me and I'd like to know what's more exciting? I mean, what—what are you talking about that we can and should be doing that we're not doing?

I realize it's unlimited out there and I certainly don't think that in any way even touches what we can do, but the human mind can only stretch so far and I really would be interested in—in what you feel we can do that we're not doing.

Mr. ROGERS. First, let me say that, for some considerable time, I was a physicist and there's nothing more exciting, nothing, than to solve an equation that nobody else has ever solved and publish it, or make a new measurement.

I remember the time that I first saw an ultrasonic sound beam in a solid. It was late Sunday night in a lab at MIT. Excitement! You couldn't beat it! I'm not talking about those things now.

Let me give you an example of what I consider exciting today in a somewhat broader context. Putting 100 members of the general public in space every year. Now, that's exciting, and there's no reason why not. We could, by the end of this decade, have 100 people drawn from the general public, from every cross-section of life brought up into space to spend a week up there. They'd blow their minds, expand their interests, strike their imagination, give the whole civilian space program political, social, cultural vitality which it doesn't have enough of today.

I could imagine a lodge up there that you could call a national park. You would be there looking out at the cosmos and down at the Earth as though you were standing at the rim of the Grand Canyon. Now, that's exciting, I think.

I'll give you another "for instance." We can now imagine having sophisticated and powerful satellites in orbit that could bring radio broadcasts to every people in the world, from every country in the world, directly at very, very modest costs. You could have your hand-held radio, which you now use to listen to WTOP, tuning in on programs directly from Brazil, New Caledonia, Japan, and do this well within a decade.

Today it's called shortwave. If you go to the Radio Shack and see a shortwave receiver or you try to use it, that's not exciting. You can hardly tune it; it costs a lot; you can carry it and nobody in this country, unless he's a radio amateur, listens to it. But I could imagine 100 countries in the world able to broadcast their interests, their activities, their point of view directly to us and we to them. Look at all we'd learn simply by listening.

And we could return to the Moon. We could put a small settlement on the Moon, not a scientific settlement necessarily. It could have scientific elements, but it would be the first step, the first extension of this permanent habitation that we're talking about in low-Earth orbit, extended to the Moon's surface. And we could do it for a lot less money than people are talking about now—about now, and we could do it with the United States leading every country in the world in doing it. That's international cooperation and I think that's exciting.

Does that help you?

Mr. SMITH. Yes, it does, it's very interesting. I think the problem that I know we've all been wrestling with here on this committee is how do we get the private sector involved? I mean, we're hearing comments from many of the people in the private sector that unless the Government, the Congress subsidizes these industries, they can't get up there, and you know, somewhere along the line, a policy is going to have to be developed here, and what are you suggesting that it should be?

I know, I guess the chairman said you shouldn't be getting into policies so maybe the question is out of order, Mr. Chairman, but I'm interested in your comment on that because——

Mr. ROGERS. Well, I would—I would say two things, Mr. Smith. One, NASA is changing; the administration is changing. The Congress did change the law. It said a year or 18 months ago that from hence forth, you would try to get the most—you would use great efforts to get the most out, and they are moving. They are changing.

I talked with them and they are—they are trying and we'll just have to see. But now I would say one more thing, and I will call upon my Defense experience for making this observation: Nobody's trying to reduce the cost of anything. Let me give you some examples.

I can now fly around the world—I can take a vacation around the world by air for less than $1,000. I can't put a pound in orbit for $1,000. I can't even come close. I can't—I can't put my keys in orbit at that rate.

If I light a bulb in low-Earth orbit, a 100-watt bulb, and I keep it lit for a year, the amortized cost of so doing—you watch it—is $100,000. By the time we're finished with the space station program, we will have livable habitation up there—it will be safe; it will be sanitary; it will be durable and it will cost hundreds of thousands of dollars a cubic foot.

Mr. SMITH. But shouldn't—shouldn't the——

Mr. ROGERS. The—the concluding statement——

Mr. SMITH. Excuse me.

Mr. ROGERS [continuing]. That I would make, and I draw upon my Defense experience, I was once in conversation with the Secretary of Defense, who shall remain nameless, and I asked him, under similar circumstances, when did a general officer ever get a medal for saving a dollar? He was incensed. He inquired. The answer was: never. The Congress, I do think, could insist that a large, or at least a sensible fraction of all the things that are going on in the civilian space area would be addressed to driving down the unit cost of such very basic things as power, as transportation, as living residential space. Driving the unit cost down. Not the total—but driving the unit cost down.

Has anybody come to you and said that they are spending $100 million to try to drive down the cost of these things?

Mr. SMITH. I think the point—I agree with what Mr. Walker said, that we certainly would like to see the private sector encouraged. I'm certainly taking that position, but I—I get discouraged when I hear the private sector come in here and say you can't—we can't do anything unless—unless we hand out lavish government subsidies to—so that they can compete.

That—otherwise, these same private—these same companies are going to go to France or to Europe and use—use their facilities to go into space. Now, that—you know, that makes it very difficult for this committee and for the Congress.

Mr. ROGERS. Well, that is getting beyond the confines of the OTA study on space stations, but I personally would only hope—I would trust that the Presidential Commission on Space, whatever else it does, will look at these two questions: One, how do you drive down the unit costs; and how do you see the private sector brought in to play increasingly large and eventually a major role in space?

Mr. Nelson. Mr. Volkmer.

Mr. Volkmer. I would just like to continue part of it.

Mr. Rogers, you mentioned drive down the unit costs. Now, how many units do you have——

Mr. Rogers. By that I mean——

Mr. Volkmer [continuing]. That you're talking about?

Mr. Rogers. By that, I mean drive down in transportation the cost per pound. I'd be pleased to see us have a lot more—a lot more—a lot more space transportation capacity, but I would like to see the cost per pound come down, the cost per watt come down, the cost per livable volume come down.

Mr. Volkmer. Well, I believe everybody agrees with you and even NASA agrees with you on that, and they are taking steps constantly to attempt to do so, filament-wound case on the SRB's to cut down the weight there so they can carry more on the shuttle. The fact that they are now in possible competition on the—in the future, on the SRB's. There are other things that they're looking at and I should say in defense of NASA that I believe that even though they don't have a specific program to do that, that they are looking at ways every day to try and reduce those costs.

The other thing I'd like to have from you—there are several things in your statement and in the report also that I was intrigued about originally, and I was wondering if we could get some specifics. How would you go about doing this?

"NASA could ensure that the space infrastructure is developed in a truly collaborative cost-sharing way with other spacefaring friending countries." Now, how are we going to do that?

Mr. Rogers. Well, in our talking—and I must hesitate just a moment because, as you know, this is a very rapidly moving area and there have been discussions between various countries and NASA since the study was completed, to which I wouldn't be privy at first hand in the first place.

But our point there, Mr. Volkmer, was to—was to observe that it is one thing for us to say that cooperation is simply allowance of somebody, without prejudice, to develop their thing and do their thing and perhaps put it in a co-orbit with us and maybe—and maybe at times exchange power or communications. That's—that's sort of at the margin, at the limit of the word "cooperation."

But we could have, as we often have in the scientific areas, and as we do in defense areas, have true collaboration in which different people, different parties, all agree to produce important elements of the whole and share responsibilities and share costs and share funding, and of the latter, we see—or at least by the time the report was prepared and issued—we saw relatively little. And that's why we did raise the question in the report in the sense that it seemed to us that it would be worth the Congress' attention to ask whether or not some or all of the $2 or $3 billion that are being talked about as being spent by other countries couldn't be spent in such a fashion that the American public wouldn't have to pay that as well.

Mr. **Volkmer**. Well, I would like to see where—in other words, where we could cooperate with ESA and with Japan and with Canada and right straight from the developing stage, and some of us looked at the whole space station concept with that idea, but then you run into such things as technology transfers and the problems that we have in this country with those type of things.

How would you answer that? You say we're going to just ignore that problem?

Mr. **Rogers**. No, I wouldn't ignore it. I would say the following two things: One, I would want to be clear in my mind as to whether there was any military connotation here, any national security matters, and at the time we wrote the report, there were none. So you are talking about economic reasons for——

Mr. **Volkmer**. That's correct.

Mr. **Rogers**. Well, if there's going to be—if we're going to lose some edge in some technological areas, we will gain in others. The other countries of the world are not where they were 20 years ago now, Mr. Volkmer, they are very, very smart and very, very aggressive and they are experienced in development and we have things to learn from them as well to teach them.

The other thing that I would say is if they would put in $2 or $3 billion, I wouldn't be adverse to seeing them pick up a few things for $2 or $3 billion because with that money saved, I'd have my people out at the crest of the wave at the next generation, the sharpest, the most advanced, the hardest driving, the most exploratory things, so I think that's the way to think of it in balance.

You wouldn't be giving it away; you'd be getting paid for it and you'd be freeing up your people.

Mr. **Volkmer**. Now, on the other hand, you have ESA—and as the way I understand it from them, they prefer to do it basically the way it's being done, rather than the integrated part because they would like to have the complete control over whatever they're doing and not having us—have anything to tell them really about that module or whatever they're going to build, whatever they want to do. The Columbia project, that's their decision; they decide what they want; and they can either expand on it later on with their own space station if they want to in the late 1990's or whatever.

Now, they prefer to do that.

Mr. **Rogers**. Well, they very well may have and—I am not that close to it. I can't comment usefully to you about it. Personally, I think it is sort of a shame.

Mr. **Volkmer**. Well, I think that we're going to see cooperation with Japan, Canada, and ESA; I think we're going to have them participating in the space station project.

The other thing is, as far as private sector, I think that, to the extent that the private sector would become involved, they're going to be involved. As far as them going out and building their own module—if we're going to use a modular-type of space station—for them to do that. Let's put it this way: I haven't had anybody tell me that they're ready to do so. Do you know of any? Do you know of any major contracting firm that's willing to do that?

Mr. **Rogers**. Mr. Volkmer, you've touched a very exposed nerve with me in raising that question. I don't—well, let me just make—I would make two general observations——

Mr. **Volkmer**. Yes, all right.

Mr. **Rogers**. The first is if they were asked by the Government to meet performance specifications, not detailed and specific engineering specifications, you wouldn't see it cost as much. You just wouldn't see it cost as much. But that is not the way that we are moving. We not only tell the industry—the Government not only tells industry what they want the industry to provide them, but how to do what it is that they're going to do to provide it.

We don't buy electricity this way; we don't buy food this way; we don't buy transportation this way, but we are continuing to buy space hardware this way. The amount of time which the space industry spends meeting all of the specific engineering and administrative criteria for turning out a watt of power adds considerably to the cost of that power, Mr. Volkmer.

That's one comment I would make. And the other comment I would make—and I almost hesitate to make it—I was reading—oftentimes as I do—with some colleagues a little while ago about the early days of the air transportation industry, and 30 years after the Wright brothers flew, we had people in this country running airlines, tens of them. By 1930 or 1932, about the same number of years after the Wright brothers flight as we are now after Sputnik, we had—I think it was the order of 100 or 200 million passenger miles a year being run by commercial people. Now, the commercial people then, and in defense, worked with the Federal Government—or they did 10 or 20 years ago—always with the notion that they would try to spin some of the defense development off and put it into the civilian world. They would try to start new industries, new plants.

There's very little of that now, Mr. Volkmer. My vision, and in my discussions, my meetings with people in the space industry—and I've had many of them since leaving OTA—suggest to me that what they try to do is to position themselves to get the next Government contract.

Now, there's no cost-reduction potential in that, Mr. Volkmer.

Mr. **Volkmer**. Thank you very much.

Mr. **Nelson**. Just one.

Mr. **Walker**. Just one, Mr. Chairman, which basically follows on that very point.

To some extent, the real question here of getting private industry involved, then, is really the investment climate that we set and what we determine as Government policy with regard to setting prices for space, setting—setting criteria for space, then, really does make a difference as to whether or not industries are going to come forward and tell us whether or not they are willing to make major—major new investments.

Is that not correct?

Mr. **Rogers**. Yes.

Mr. **Walker**. And risk capital, in particular, is sensitive to the kind of climate that we set. If risk capital believes that the climate is going to be dictated by Government policy, it will take no risks. If it believes that their risks are likely to be heavily profitable, they—they will, at that point, begin to take the kinds of risks that have some potential.

Because I think you said, in either your statement or in what you said, that from an engineering standpoint, and from a lot of other things, there's practically nothing limiting us in space at the present time; that we can do most anything we can think about doing, at least in low-Earth orbit at the present time, so that what is really holding up the money is something else and to—to large extent, it's a question of policy as to whether or not that risk capital is put forward. Is that not correct?

Mr. **Rogers.** To a very great extent, to a very great extent. You know, I can't help but believe—I could be incorrect, but I can't help but believe that if the Government were to go out and say, "Of this 100 kilowatts, we will purchase 10 kilowatts. Don't tell us how you design it, develop it, produce it, install it, test it, but we want insurance; we want warranties—we're not going to take a risk with the other 90 percent, but we'll take the risk for 10 percent of it and we'll give you a 10-year contract for delivering electricity to us in orbit."

I find it very difficult to believe that the American industry wouldn't respond to that.

Mr. **Walker.** And on the other side of the equation, if we would tell industry that we will give them tax free the profits from products made in space for a period of 10 years, that would also change the investment climate, would it not?

Mr. **Rogers.** Yes. Yes.

Mr. **Walker.** Thank you, Mr. Chairman.

Mr. **Nelson.** Mr. Rogers, you have stated that the general public should be more involved in NASA policy decisions. If you were the NASA Administrator, how would you do things differently?

Mr. **Rogers.** I—I don't mean to be understood by that, Mr. Nelson, that—that they ought to be sitting in at the Administrator's briefings, conferences. What we mean by that is that in—just as we do in many, many, many other areas of interest and concern to the American public, we should have a great many more people in the American public feeling, experiencing, being close to the decisions to the activities that are being conducted. Now, the scientists do; the engineers do; the space industry people do, but by and large, the general public does not.

There was a poll conducted and reported in New Scientist within the past month, a very interesting poll. The question was asked: What's the most important thing since the Second World War in the area of science and technology, and the answer was space, space exploration.

The question then was asked: What's the most important thing for us to put our governmental money on, and space was not a part of it. Now, what that tells you is then, therefore, unlike education, unlike housing, unlike employment, space is a very interesting thing to many people, but they don't associate with it personally. They don't relate to it personally. They don't see themselves personally involved.

And we think that that's a shame and when we wrote the report, one of the things that we said that the Congress could debate was the matter of seeing a great deal of—a great many more people drawn from the general public allowed to visit space.

We—and I drew the contrast in my testimony today between the national debate on something that really matters, life and death, in the military area in space with SDI debates, and the very near absence of debate in the civilian space area. That's a shame.

Mr. NELSON. Well, do I take it from what you've said is that the Civilian-in-Space Program that NASA has started, you would heartily concur——

Mr. ROGERS. Absolutely.

Mr. NELSON. You would just like to see more of it.

Mr. ROGERS. Absolutely.

Mr. NELSON. Well——

Mr. ROGERS. I was going to say, mathematicians have an expression, and that is: the ratio of something to nothing is infinite, so putting one school teacher and one senator there is absolutely right on. We think—we thought—many of the people we talked to suggested that we should be able to and should strike out for putting hundreds of people up there.

Mr. NELSON. And is there any reason for you to believe that that's not going to occur as the transportation system grows and as we get the capability of putting more people on?

Mr. ROGERS. Well, someone will have to do it. Someone will have to appreciate that it's important to the country's interests to see that it does. My sense is that the leadership at NASA would say that that is important and would see it, but it takes that first drive, you know, that initiative. And I think—I think the Congress would be a great deal more appreciative of the intangible but great value of doing that than would the scientific and technological communities.

That would be my one person's—one person's judgment.

Mr. NELSON. The way I read the tea leaves, I think that that's exactly where we're going to see the Civilian-in-Space Program go. I think we're going to see a journalist fly; I think we're going to see an artist; I think we'll see a writer; I think we'll see a college professor; I think there'll be a whole host of people, as the capability is there, the capacity is there.

Mr. ROGERS. Well, Mr. Chairman, and if John will forgive me, it should happen in my lifetime. You're a young man. What we're talking about here is rate. I think that almost all of the pieces are in place, what now is required is a sense of the uniqueness of the American experience.

There's no other country in the world that would see its general public go up into space. What an extraordinary example of what we are, doing a thing like that.

Mr. NELSON. Well, I—I'm reminded that I have encouraged NASA, and I think they've done a commendable job to try to encourage Members of Congress and staff to go see a launch, go see a landing, go to the National Air and Space Musuem. You might be interested to know—this is just a piece of trivia, but it sort of borders on what we're talking—did you know that the fourth largest tourist attraction in the State of Florida is the Kennedy Space Center? In numbers of people that visit annually, it's the fourth largest tourist attraction, and, you know, there's a subcontractor there to NASA—a contractor there to NASA that runs that tourist operation, which they call Spaceport U.S.A. Used to be called the Visitors Information Center.

So that—that latent interest is certainly there and it's propelling certain people to the tune of about 3 million folks a year on their vacations to Florida to go there.

Mr. **Rogers.** You're absolutely correct and it was with—not with that specific example in mind because I was ignorant of it, but it's with the very, very great sense of the great general interest of the general public if we could only focus it, make it more specific, starting getting upstart getting up, many more of us.

Mr. **Nelson.** Well, I welcome you to continue to share your thoughts with us on these and any other subjects and you do not have to have a formal request from us.

Mr. **Rogers.** Thank you very much.

Mr. **Nelson.** You can share informally with us and Mr. Walker and I will be delighted to receive your comments.

Now, let's call our panel up and we'll proceed forthwith.

I would like to ask the panel if—we will submit your formal statements for the record and I would like for you to just share with us in open conversational format your conclusions and thoughts of your presentations and then we'll get into the questions after we've heard from all of you.

So let's ask Dr. Drew if you will start.

STATEMENTS OF DR. RUSSELL C. DREW, VICE PRESIDENT, PROFESSIONAL ACTIVITIES, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.; DR. JOHN L. McLUCAS, PRESIDENT, AMERICAN INSTITUTE FOR AERONAUTICS AND ASTRONAUTICS; DR. JOHN W. ROBINSON, CHAIRMAN, TASK FORCE ON CIVILIAN SPACE POLICY, AEROSPACE DIVISION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS; AND DR. GLEN P. WILSON, EXECUTIVE DIRECTOR, NATIONAL SPACE INSTITUTE

Dr. **Drew.** Yes, Mr. Nelson.

Mr. **Nelson.** Push the microphone on, Dr. Drew. There you go.

Dr. **Drew.** Thank you.

I'd like to emphasize three points that we cover in our statement today. I'm here on behalf of the Institute of Electrical and Electronic Engineers. As you know, we have a very major role in supporting the technology that's made the U.S. Space Program possible. So we have a very special interest in the future of the Space Program, the process of goalsetting, the issues that you've discussed here today.

I particularly want to cover these three points to try and highlight what I think are points that are very valuable and important to the discussion that—that you've undertaken.

First of all, the question of a human presence in space. The—the issue of a space station or "a" space station, we believe, revolves very vitally and intimately around the question of the policy of the United States vis-a-vis this simple point, and that is, a human presence in space.

Mr. Chairman, I happened to be working in the White House as part of the Office of the President's Science Adviser about 15 years ago when the question of what to do after Apollo was being debated and at that time, the question of a space station or, it turns out, a space shuttle, was the principal issue that was being confronted, and as part of that, we asked ourselves the following question: We said, can we—at that time we were recommending the President—but can we recommend to the President or to the Congress of the United States that the United States abandon the ability and the continued involvement of the human presence in space? And our answer to that was clearly no, and we felt that the—the space shuttle was a very important and a crucial item in continuing to enable us to exercise that decision, and we believe, as a matter of fact, that that—that is a policy decision that the United States has made, to continue a manned or, if you will, a human presence in space.

The space station or "a" space station, I believe, can be viewed in very much the same light. It is the vital item of infrastructure which enables us to continue to exercise that national policy, and that is a human presence in space. The extension of the capability of the—of the human intellect on the scene is going to be, and we believe will continue to be a very vital part of our space effort.

We like to think of the Antarctica analogy. We can very clearly perform a great deal of what is done in Antarctica with unmanned systems, but it turns out that this vital presence of the—of the human being there is—is both necessary and accepted, part of what we mean by exploring and extending our horizons. So we view that as—as being a No. 1 issue which we think the Congress has already answered, and that is, that we will continue to maintain that presence.

For—in addressing the second point, and that is, the OTA's analysis and study, we tended to find their study very useful, valuable, a great deal of important observations and analysis there. We differ with the OTA in one important point and that is, that you have to have a very clearly articulated set of we're going to do this or we're going to do that in order to make the commitment to develop this kind of infrastructure.

Frankly, we think the infrastructure should be more general purpose than to be targeted to a specific narrow set of objectives. It ought to have more of the—what we could call the battleship mentality applied to it. That is, it needs to be repairable; it needs to have the kind of approach which has been characteristic of the ships at sea. That is, it must be able to support man for long periods of time, long, long duration, and in order to do that effectively, we're going to have to learn a great deal and that's part of the challenge. We should keep in mind this question of repairability on orbit maintainability in order to be able to achieve the kind of capability that we think is necessary.

By having growth capability, and I think it lends itself beautifully to—to growth, additional modules, the issue of whether or not it has 100 kilowatts—it should have an opening power supply which has growth capabilities that can be added to. When we put a power system in place on the Earth, we don't size it for its ultimate delivery capability necessarily; we build in flexibility to expand and, in fact, we interconnect. Our power systems today are very sophisticated interconnected systems where we transfer power back and forth, so you don't have to make a final decision on what ultimate power levels you need now. You make the decision to permit modularity and growth to be part of the system design. We think that's an important part of the—the Space Station Program.

We would agree, however, along with this belief that firm, fixed goals are not absolutely required at this point to go forward with the commitment to a space station. Nevertheless, a National Commission on Space is very important. We've advocated this earlier. We'll continue to advocate a—a mechanism for promoting a continuing dialog on the pace at which we proceed toward these long-term objectives.

There's no question in our minds that manned exploration of—I won't say the cosmos, but certainly manned exploration in space will continue, that we'll want to go to the planets one day. We will go to the Moon. This is part of our future. The question is just when in this process are we going to be ready and do we want to make that step?

Finally, let me cover international cooperation. You've touched on this, and I think it's a very important issue. It's an issue which has several aspects and balancing factors. We'd like to see the participation of nations which we would view as being collaborators in space and in many other areas to join with us. We see their investment as being a valuable part of joining ourselves in a political sense.

It's been pointed out that technology transfer is an issue. Frankly, we think that this may be a red herring at the present time. It's been pointed out that the potential collaborators that we've been talking about have demonstrated an independent capability that's an extremely valuable part of—of their technology thrust forward and that we believe they can become suitable partners and not so much junior partners that we're training and helping along, but rather, full collaborators.

In order to have that happen, though, we believe that the kind of dialog that NASA has conducted needs to, perhaps, consider more creative structures in which we can sit down and hammer out a coordinated development approach. It's the sort of conference activity that's going on in Geneva, but really with very friendly collaborators to try to define a partnership in which their contributions and their access in the utilization of this vehicle, a space station, can be commensurate with both of our objectives.

That means we may have to give a little on some aspects of the program and balance our interests with theirs. We're not sure that the political will is consistent with that, but we can certainly see from an engineering technical standpoint that it would be a suitable way to go.

Well, our bottom line is we support this program. We support the administration's request this year, even though it has been reduced in the budget process. We believe that the time is right now for us to do something we haven't quite done before, and that is to get some sort of sense of the Congress statement, a, quote, commitment. I'm not quite sure how we do that to—to proceed to a manned habitat in Earth orbit.

Thank you very much, Mr. Chairman.

[The prepared statement of Dr. Drew follows:]

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STATEMENT

of

DR. RUSSELL C. DREW

of the

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS

before the

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

regarding

CIVILIAN SPACE STATIONS AND THE U.S. FUTURE IN SPACE:

A report prepared by the Congressional Office of Technology Assessment

March 26, 1985

Mr. Chairman:

It is a pleasure to have this opportunity to appear before your Subcommittee to discuss a number of major issues confronting the U.S. program to develop a space station. My name is Russell Drew, and I am the Chairman of the United States Activities Board of the Institute of Electrical and Electronics Engineers (IEEE). The IEEE is the world's largest technical professional society, with over 260,000 members in 157 countries. In the United States there are more than 210,000 members, working in industry, Government and academia. The U.S. Activities Board provides a forum for developing public policy positions on behalf of these members.

Our members are active in a wide range of technologies that are important to the space program and to U.S. industrial competitiveness. We therefore have a special interest in the future of the U.S. space program and the role that this program plays in fostering the technology advances that will continue to fuel the high technology needs of our national industrial enterprise. Our views represent an amalgam of many perspectives, most of which are not closely allied with NASA or its programs.

MAN-IN-SPACE

In order to set my remarks in context, it will be necessary to go back about fifteen years, when the nation was basking in the very positive glow of the first Apollo lunar landings. At that time, a major question facing the U.S. was -- What next in space? One of the candidates for a national commitment at that time was a space station. However, the decision was ultimately made to proceed with development of a space shuttle, a system that provides the capability of transporting both man and satellites into space and returning them to earth in a protected environment. When the decision to commit to a space shuttle was being debated, much of the discussion revolved around the question of cost-effectiveness of such a system vis-a-vis expendable launch vehicles. The question of a continued manned presence in space played only a very minor role in the public debate. For many of us who were involved with that decision, however, this was the vital element that tipped the scales in favor of a shuttle development program. We asked ourselves, "Can the U.S. abandon manned spaceflight?" The answer was clearly -- No. And from that response, the shuttle appeared to be the most advantageous next step for the U.S.

Today, with the shuttle operational and performing about as predicted, we are faced with another major commitment that is an extension of the shuttle decision made over a decade ago. This decision is very much involved with the future of man's presence in space, like the commitment that was made by the President and the Congress to support the shuttle program.

We believe that a space station is the proper next step for the U.S. if we are to continue an effective manned presence in space.

THE OTA STUDY

The Office of Technology Assessment has produced a valuable, and very comprehensive study of the issues that should be considered in making such a national commitment. They have explored the range of decision options that can be considered as well as a diversity of configurations that could be developed under the very general rubric "space station". We find many of the observations of the OTA study completely consistent with ours in the IEEE. There is one very important point at which we diverge from the general tenor of the OTA study. This is the question of the importance and necessity of "nationally agreed upon long-term goals" and the character of those goals.

In principle, it is always wise to have such well articulated goals to insure the adequacy of the programs that are aimed toward them. The OTA has suggested that these goals be "nationally agreed." National agreement clearly is desirable in order to ensure popular support for the funding commitments needed. All these elements make for a very tidy and satisfying decision-making environment -- but do not correspond to the reality of the situation that often exists regarding Government program initiatives. National agreement on a program is largely a function of the consensus judgment of the Congress and the President, with input from interested constituencies. There is no grass-roots mechanism for arriving at such national goals -- they must be articulated by our national leaders and then ratified through the public processes of government.

In this regard, we agree with the OTA that action should be taken to improve the process of goal-setting by prompt establishment of the National Commission on Space created by action of the 98th Congress. But it is not necessary or desirable to delay a commitment to a space station while the Commission is being constituted.

The reasons are relatively straightforward: (and this is where we differ from the OTA view) — we already have a goal that has been supported by the Congress for many years, that is, a commitment to continue to support a manned presence in space and to expand the utility and effectiveness of that manned presence.

This is the basic goal that drove the nation to place a man on the moon and to carry out the Skylab missions. It was, as I have noted, an important part of the rationale for development of the shuttle and it is fundamental to the decision to support a space station program. Viewed in this light, therefore, it is not necessary to make a national commitment to put men on Mars or a base on the Moon, or to reduce "the unit cost of space activities" (as suggested by OTA) as a precursor to the commitment to a space station. Similarly, the station is not "justified" by a specific mission or set of tasks, but rather is a multi-purpose element in a growing infrastructure that is necessary for us to achieve the basic goal I have outlined above.

Given this perspective, the apparently somewhat weak NASA statement that the space station is the "logical next step" in our exploitation of space is actually a rather strong statement in support of the program. For these reasons, and others we would be pleased to elaborate, the IEEE supports the concept of a space station, and we suggest the following five point program:

1. Commit now to the development and implementation of the infrastructure needed to continue man's active involvement in space.
2. Establish a permanent habitat for space crews and passengers in low earth orbit that will enable a full range of staging activities for future manned and unmanned missions. Ensure that the habitat is planned to permit growth and the incorporation of companion systems, both manned and unmanned.
3. Pursue international cooperation with qualified partners on three fronts---shared funding, technology and responsibilities.
4. Incorporate advanced remotely-controlled systems as a complement to the on-board crew.
5. Foster new and innovative opportunities for commercial industrial utilization of the manned habitat and other platforms.

The pace at which the program is conducted should not be such that other important space objectives in the science and applications programs are sacrificed in order to complete the space station.

In this context, Mr. Chairman, we are pleased to endorse the Administration's approach thus far and we support the proposed 1986 budget requested for this program. The funds requested will enable continued progress on the definition of system configurations, basic technology developments and further work with the user community on the capabilities to include as part of the station complex.

INTERNATIONAL COOPERATION

It is particularly important that the early discussions with potential foreign contributors to this program be brought to a satisfactory conclusion. This will call for a very delicate balancing of a number of important considerations. Let me highlight a few of them.

First, the aspirations of the European nations that are part of ESA need to be recognized and balanced with our own legitimate aspirations for our space efforts. The U.S. has supported its space program for very practical reasons, among which has been to improve and extend our national self-image and our nation's image in the eyes of the rest of the world. Success in Apollo has been a psychic "plus" on which we have depended in many other areas. It was a national effort for which we could take national credit and pride. If we now move to a more shared international effort, we will loose much of this benefit. Perhaps it is not as important to us now as it was then. This is a judgment that we in the IEEE are not well-equipped to make, but which must be established through joint Congressional-Executive Branch action. In dealing with the terms and conditions of international participation, however, this consideration should be explicitly recognized.

We have also prided ourselves on our record of success. The lessons we had to learn in order to achieve this success record were painfully obtained through experiences in the early days of the program and then refined and polished in the course of two decades of manned flight experience. Any cooperative program must ensure that the conditions that are necessary to give the maximum probability of success are maintained and not sacrificed to achieve cooperation or non-U.S. financial contributions. This, like the previous consideration, requires careful and detailed consideration as we define the nature of international participation.

Today, our potential partners in a space station program have demonstrated a technical capacity that is sophisticated and capable of independent successes. They have the ability to become true partners and our approach to them should recognize this fact. It would appear desirable to structure a development authority that was transnational, if the proper agreements can be reached. In such a structure, there would be both major and minor partners, and the rights of both would need to be protected. This will be a major challenge in the coming months.

We support the Administration's efforts to move toward this objective under the conditions we have outlined.

This concludes my prepared remarks, Mr. Chairman. I will be pleased to respond to any questions that you or other members of the subcommittee may have.

Mr. NELSON. Thank you, Dr. Drew.

Dr. McLucas.

Dr. McLUCAS. Thank you, Mr. Chairman.

Mine doesn't light up like the others, but I think it's working.

Since you suggested we take a conversational tone, I thought I would go back to a point you made about putting a journalist in orbit. I got—I received a call from a journalist a couple of weeks ago—I guess he was thinking back to my experience in the Pentagon when he phrased his question, which was: "Don't you think a journalist ought to go into orbit?" to which I, of course, said, "Yes," and he said, "Would I leave my first amendment rights on the ground if I went into space or could I report freely from up there or would some person from the Pentagon try to tell what I could say?"

Let me go to the remarks I wanted to make and I'll try to make them quite brief. First of all, the matter that was—the material that was submitted to you might appear slightly dated because it is not updated in accordance with the meetings you had here a few days ago. Let me just make a general observation.

I guess AIAA is not unique in thinking that one of the principal drivers in the U.S. economy is the money that's spent on research and development; and certainly NASA is an agency which, I think, is most efficient in taking that general concept and converting it into industrial growth in the United States. So we're always happy to testify on the NASA budget because we have that basic feeling that this is doing great things for the future of the economy of the country.

I cite only two examples very briefly. One in the satellite communications, which is the field I'm now working in, where during the 1960's, NASA spent roughly a billion dollars. That created a $3 billion-a-year industry, from which we are all profiting now. I don't have to mention the work which they did in aviation over the years, which has led to a $50 billion industry.

Let me go to a few specifics. First, I guess I should apologize to Tom Rogers for calling this "the" space station, but we were asked to comment on the space station. I think that the most appropriate question that could be asked about it is "what is it for?" And it seems to me that the answer to that is, it is for opening up opportunities in space. We need to find out what can be done in space. There's much exploratory activity, call it research or whatever, discovery, invention and so on, which the space station will make feasible and which we cannot now describe.

I think, in answer to the comment that we ought to have a very modern program, all countries that are involved in space, including the Soviet Union, think that a permanent manned presence in space is an essential. So in that sense, I think we have a modern program when we go for the space station.

One way to look at the space station, then, is that you're committing money to a national facility which will find many uses, many of which cannot now be specified. We do the same thing when we put money into a wind tunnel or a high-energy physics facility. And I think this is somewhat in that category, but obviously it's a much more high-visibility version thereof. And let us not ignore that almost everything we do in space is done at least with one eye on how this looks in providing—in preserving U.S. leadership in space. Some people think that's a fluff, I guess, but those of us closer to the business, I believe, have a strong feeling that U.S. leadership is something we don't dare lose for a whole host of reasons.

As for the exact level of funding that ought to go to the space station at this time, it seems to me that this is the most critical time. We have not decided on what the space station will consist of, therefore, the next step is to spend money on studies, not on space stations, and those studies are going to be terribly critical in deciding what space station will eventually evolve. Therefore, we would not want to see money available for these studies cut back. We don't want to short-change those studies.

Let me make one comment about the international aspect, which has already been touched on several times. It seems to me that the space station, because we're starting with an emphasis on international cooperation early on, provides maybe the best example we've had so far of an opportunity for international cooperation. I sat in on some sessions in Germany where people from a number of nations were represented and they were all very anxious, as we know from subsequent events, to cooperate with us. So the international aspect of this is terribly important.

I would support Congressman Volkmer's comment when he said that the Europeans do not want to play second fiddle. They don't want to be submerged in an overall so-called international program where their role is so diminished that it gets no visibility. In fact, they said specifically when I was there with them that they want an identifiable module where they can paint their name on it like we paint the "United States" and everyone can see that flying and see how important it is.

Let me make a comment about space transportation in general—I'm sorry, not in general—with respect to the shuttle. Last year we preserved the option for a fifth orbiter. This year, I see signs that we're going to support that again, and I think that's a terrific thing to do because I don't know where we'd be if we lost an orbiter and didn't have a fifth one coming along.

I think we're all thrilled when we saw how a manned space capability, like an orbiter, can take on a mission which was unplanned—for example, those two communication satellites that were lost and which were retrieved while, I think, several billion people were watching that operation. A totally unplanned activity and yet one which turned out to be very important.

I have a couple of items that I would just mention in passing. I was worried about the advanced x-ray astronomy facility, the space infrared telescope. I see this subcommittee is taking care of those, and moneys also have been made available for the solar terrestial physics program. I think those are all very worthwhile.

In summing up, I would say that it seems to me that looking at the NASA budget overall as it was submitted, it's quite responsive to what we really need from a technology standpoint in the United States; and that's where I see NASA's principle role, as advancing U.S. technology; and second, that the changes that I have seen that the committee has made are making the program even more worthwhile.

I thank you, Mr. Chairman.

[The prepared statement of Dr. McLucas follows:]

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Statement to

Subcommittee on Space Science and Applications
Committee on Science and Technology
United States House of Representatives

by

Dr. John L. McLucas
President, AIAA

March 26, 1985

American Institute of Aeronautics and Astronautics

Thank you for the opportunity to share with you our views on the proposed NASA budget for FY 1986.

The American Institute of Aeronautics and Astronautics is a non-profit technical society with an international membership of over 35,000 professionals representing the aerospace industry, academia and government. Our purpose is to advance the arts, science and technology of aeronautics and astronautics both for the welfare of our nation and the benefit of mankind. One of our principal activities is to apply the capabilities of our membership in areas of national concern where we can contribute. NASA's portion of our national space program is just such an area. Consequently, we appreciate your invitation to be here today.

Mr. Chairman, before beginning our detailed commentary on the proposed NASA budget, I have one general observation which I feel is vital to your understanding of our position. In addition to being technologically informed, we like to think of ourselves as political realists. Therefore, in past years we have scrupulously avoided insisting on ever-bigger NASA budgets because we recognize the pressures you face in Congress. Nevertheless, we strongly believe and have often stated that increased federal investment in research and technology are among the most productive steps that the government can take to promote future national economic vitality.

There are indeed many examples in aerospace alone to illustrate the considerable direct financial return that can be realized from prudent but imaginative investments of federal tax dollars. NASA's expenditure of less than a billion dollars in satellite communications technology over the 1960-1973 time period, for example, has generated a $3 billion annual revenue in satellite and ground hardware and services that during 1984 returned over $300 million to the federal treasury in direct personal income taxes alone, not counting corporate or excise taxes or the ripple effect of direct jobs.

Aviation is another example. Founded and nurtured during its early years almost wholly by federal funds, today's aviation industry will generate over $50 billion in 1985. The benefits do not stop there, however, because aerospace has become the nation's second largest employer, and as such provides jobs and tax dollars, as well as technological advances.

Over the years there have been many attempts to quantify the direct cash benefit from an investment of federal funds in NASA. Although they differ in detail, all serious studies of the payoffs from research and development show that they are major sources of economic growth in an advanced society. NASA, which supports the development of frontier technologies in both space and aviation, is in the forefront of this contribution to our nation's well-being.

Therefore, this year, at a time when both the Congress and the Administration are searching for ways to produce future wealth, stimulate growth, and balance and stabilize the federal budget in the long term, we urge you and your committee to lead the long-needed Congressional examination of the proper level of federal investment in research and technology. The Committee's current study of federal science policy is an important step in this direction. In the course of this and future budgetary debates on whether to cut federal outlays or use those funds to produce additional wealth-producing investments, we believe that a strong case can and must be made for *more*, not less, federal spending for research and technology, including funds for NASA.

Such a shift in federal spending patterns, we believe, is one of the few ways the budget can be balanced and fiscal stability restored. This fact may not be widely recognized this year, or even next, but it is essential to a sound economic future for this nation. And now, Mr. Chairman, I would like to address my remarks to the NASA FY 86 budget for Space.

* * *

It is important to note that many significant events have occurred since we gave you our views on NASA's proposed budget last year. Congress has directed establishment of the National Commission on Space and, in a related move, the President directed the formulation of a National Space Strategy. DOD is acquiring a Unified Space Command and has established a Strategic

Defense Initiative (SDI) Office with a charter that encompasses a wide range of advanced space-related technology developments, including many which inevitably overlap those of NASA. Arms Control talks have resumed, and the United States has undertaken initiatives to re-establish large-scale cooperative ventures in space with the Soviet Union. Our astronauts have spectacularly shown their ability to salvage satellites in space, thereby demonstrating that humans in space are needed to correct the errors of humans on earth. Meanwhile, we are having to deal with competition in space abroad and a budgetary deficit at home, both of which are increasing and neither of which we can afford to ignore.

All of these events affect our consideration of NASA's budget for FY 86. The AIAA seeks to promote informed decisions on the development and application of space systems and technology. We, as you, realize that space systems represent substantial investments and take many years to develop. So it is essential to find out as soon as possible what we as a nation can achieve, by when, at what cost, and with what expected return. The other side of the coin is that, at the same time, we must avoid premature decisions that appear fiscally attractive today but inadvertently cut off a host of valuable options for tomorrow, impeding the technology-stimulating growth which has so effectively created new jobs and improved our economics and social well-being. These thoughts are particularly relevant at this time because the National Commission on Space has yet to begin its deliberations. Congress mandated it last year to develop a long range plan for our civilian space program. The AIAA, along with others, urged in last year's testimony that just such a plan be prepared so that future budgets could be formulated with appropriate perspective.

This year we have organized our remarks into the areas of Space Station, Space Transportation, Space Science and Applications, Space Research and Technology and Space Commercialization. We believe that this year the proposed budget continues to move close to meeting the AIAA-supported objective of maintaining U.S. leadership in space.

Space Station

The Space Station offers relatively permanent access to a unique set of conditions: zero gravity, near-perfect vacuum, unfiltered sunlight, and a reasonably sterile environment.

Questions have been posed by members of the scientific community, congressional committees and others on whether we could meet our space station goals with far less costly facilities. The debate has been underscored by negative reports from prestigious institutions such as the National Academy of Sciences and more recently the Office of Technology Assessment.

The recent Office of Technology Assessment report follows a familiar progression of questions starting with "What is it for?" The typical reaction to this question is to examine the mission model and then judge the need for the Space Station against the mission model. Unfortunately, the most important commercial products and services of the Space Station will probably be based on things we haven't yet discovered, and so aren't included in the mission model. In fact, the major contribution the Space Station will make is difficult to show on a mission model since its main contributions are: speeding the process of discovery and invention, and providing vital experience in space operations. The real mission model will only evolve after the new research facility has been operational for a few years.

So the answer to "What is it for?" is simply: to speed the process of discovery and invention with a permanent facility in the unique conditions of space. In this function it should be judged as an operational and research tool in the same way as a National Laboratory wind tunnel or high energy physics facility.

AIAA finds the OTA report, when purged of its peculiarities in argumentation, in fact makes a compelling case for a space station as an essential element of the infrastructure which will open up all of space for human exploration and exploitation. We share OTA's desire for a "truly modern civilian space program" (p. 126) and point out that the Soviet Union and Europe agree that the capability for long-duration human operations in low Earth orbit is an absolutely essential component of such a "modern" program. We believe that the basic conclusion that Congress should draw from OTA's report is the need to move ahead with the station as a necessary next step in space.

We do have a concern at this point in the Space Station development. This is the time in the total development cycle of any space system when the technological pitfalls must be discovered and strategies made for avoiding them. If we really mean to cut overall costs, then we must keep in mind that every dollar spent now in the conceptual phase has the potential leverage to reduce costs when it comes to full-scale development. It is generally recognized that a space station would be a means to an end and not an end in itself. The National Commission on Space must help determine what that end should be. Clearly the Commission will need all the help it can get, particularly from the knowledge and insights that the current NASA Space Station Studies are generating. Accordingly, it is important at this time that those studies be maintained at a scope and depth such as to promote innovation and initiative, particularly with regard to the advanced technology development. So, from the standpoints of future savings and effective long-range planning, the AIAA recommends that the proposed funding for those studies be sustained.

Space Transportation

In the area of space transportation, we were gratified last year that Congress acted to preserve the option for a fifth Orbiter by augmenting funding for structural spares to retain vital contractor skills. The justification was clear then. As time passes it gets even clearer, namely, we need assurance of adequate space transportation system traffic capacity and of being able to recover as quickly as possible from the potential loss of one of the other four Orbiters. As the launch activities increase, especially to meet the requriements of SDI, a four Orbiter fleet may well be insufficient. Elimination of the fifth Orbiter option could be disastrous and we strongly urge Congress to restore the necessary funding to retain a viable production capability until, at least, Shuttle operations are more mature. For a system that is to be the nation's transportation centerpiece for the next twenty years or more, it is vital that our production base be sustained.

Looking beyond the Orbiter toward our future needs and priorities in space transportation, clearly there are many issues to weigh carefully. Given the decades of lead time that history tells us are needed, we applaud the President's decision for a joint NASA/DOD study on the next generation Shuttle, which would increase capabilities and be more economical. A significant decrease in launch costs is necessary if true space exploitation is ever to occur. In this connection, NASA must be encouraged to continue its pursuit of better techniques for thermal protection as well as advances in both propulsion and in light-weight materials and structures in order to increase payload capacity, reliability, and operational flexibility.

We are gratified to see included as a new start this year the Orbiting Maneuvering Vehicle (OMV), a system that the AIAA first advocated as an "interorbital transfer stage" in our 1973 study on "New Transportation Systems." The OMV will effectively increase the Shuttle's operating capability by allowing delivery, retrieval and servicing of payloads up to 1400 nautical miles from the orbiter.

Space Science and Applications

As the President's Directive on National Space Strategy points out, civil scientific research and exploration in space is an essential element of U.S. leadership in space. It is also a vehicle for scientific advancement and long-term economic benefits as well as international cooperation. We are pleased, therefore, that the budget for Space Science and Applications proposed by NASA represents a 10 percent increase in real dollars over that for FY 85.

Nevertheless, we regret the lack of new starts in this vital area. For example, while the Hubble Space Telescope (HST) is moving forward toward a 1986 launch, several other important missions recommended by the National Academy of Sciences in other wavelengths of the spectrum are still waiting after five to ten years for a new start. These include the Solar Optical Telescope (SOT), the Advanced X-ray Astronomy Facility (AXAF), and the Space Infrared Telescope Facility (SIRTF). We are pleased to see the release of the Announcement of Opportunity for AXAF. Funds for a Phase B study of SIRTF, however, were not included in the FY 85 budget and still do not appear in FY 86.

We also regret that the TOPEX satellite, intended to measure ocean topography, was not approved as a new start. This appears to be a low risk/low investment program offering substantial benefits to oceanography and meteorology as well as to the fishing and shipping industries. TOPEX data are fundamental for the World Climate Research Program (WCRP), an international 10-year effort beginning in 1985. The TOPEX program will lead to improved understanding of the interaction between the oceans and atmosphere and the modeling and prediction of their weather and climate. Enhanced science on the interaction between weather and ocean circulation will be provided by TOPEX if flown simultaneously with the Navy's NROSS scatterometer, presently scheduled for a late 1989 launch. The European Space Agency (ESA) satellite ERS-1, also scheduled for launch in 1989, will provide coverage of the polar regions. Combined TOPEX/NROSS/ERS-1 data sets will yield accurate measurements of large-scale currents and polar ice sheets.

Since TOPEX is a part of a joint US/French scientific project, it would provide the added benefit of supporting the role of the U.S. in fostering international cooperation in space. Unless Congress supports satellite oceanography at this time, the U.S. may quickly fall behind in this important field, especially in view of imminent foreign efforts to move forward independently.

Another critical program not yet funded is the International Solar Terrestrial Physics Program, which will use three U.S. satellites to investigate the solar wind, the earth's magnetosphere, and their interactions. This mission has stimulated great interest among the Soviet, Chinese, European, and Japanese scientific communities, and the latter two may go ahead without the U.S. if we cannot soon make up our minds to participate.

In the view of the AIAA, both TOPEX and the International

Solar Terrestrial Physics Program represent, by their omission, cases where budgetary decisions intended to save a relatively small amount of money now may kick back later in the form of economic and leadership losses. We recommend that they be funded as new starts this year.

The Research and Analysis (R&A) portion of the budget can be regarded, after all else is said and done, as the ultimate measure of our national commitment to getting the most value for every dollar spent on our Space Science and Applications activities. Therefore, we are pleased to see NASA propose an increase in R&A funding this year.

In sum, as regards the segment of the Space Science and Applications budget proposal we have just discussed, we see some worrisome omissions that this committee should consider rectifying.

Space Research & Technology

In one way or another, each of the areas we have just discussed pre-supposes a solid foundation of technological development. We have noted some of these needs in passing. We now want to make our concerns more explicit by commenting on the area of Space Research and Technology (SR&T). Overall, we think that NASA's proposed SR&T Program is a good one. There are, however, some segments of it that merit special attention, in our view.

In the area of propulsion technology, again we find a generally sound and forward-looking program. Nevertheless, we note that there is no budget allocation to increase the thrust level of the Space Shuttle Main Engine (SSME) above 109 percent, the current level the Shuttle can accept. Such an increase is highly desirable for greater Shuttle performance as well as for future applications such as heavy lift cargo vehicles.

Neither does NASA evidently plan to work on: (1) advanced solid rocket propulsion technologies; (2) use of storable propellant for orbital transfer functions; (3) development of magnetoplasmadynamic (MPD) devices for auxiliary propulsion; and (4) development of extendable rocket nozzles. We see these as gaps that should be filled in the program. Furthermore, in developing technology for the next generation SSME, NASA evidently plans to use the current SSME as a test bed. We strongly recommend that NASA establish facilities as well for the testing of individual advanced engine components, such as turbopump assemblies and thrust chambers. Component testing is a highly efficient and cost-effective technique for engine development.

In the area of materials and structures, we have already pointed to the need for continued improvements in thermal protection systems and in light-weight materials and structures. These advances, we are pleased to note, continue to be pursued. Now that there is a national commitment to a space station, the technological issues related to large space structures, including their control and testing, must be resolved. NASA, in our view, has done an excellent job in identifying the critical problems and making progress toward solving them.

NASA and DOD share many common space interests. Indeed, the overlapping of NASA and DOD space research and development was explicitly acknowledged by Congress in the National Space Act of 1958. This year the point is underscored by the presence of the SDI research program, about which we would like to make a point. In its recent position paper, "Ballistic Missile Defense - A Challenge to Space Technology," the AIAA expressed its concern that the SDI Program not be unwittingly allowed to drain needed resources away from other programs whose requirements and potential are already established. This concern, we believe, applies to several areas of advanced technology development important to NASA. These areas include: (1) launch vehicles and operations; (2) on-orbit construction and maintenance; (3) high-speed on-board data processing; (4) radiation-hardened large-scale integrated circuitry; (5) high data rate communications; (6) surveillance, acquisition and tracking sensors; and (7) automation and artificial intelligence. To these we can add the SP-100 Program on space nuclear power sources, which is now a joint endeavor of NASA and the SDI Program along with DOE.

In simple terms, the risk we see is that any change made in the SDI Program may inadvertently produce an adverse effect on the basic space related R&D being conducted by NASA. We see the need, therefore, for a general awareness of this risk along with appropriate steps to protect NASA against it.

Fortunately, opportunities exist which can help to assure such protection. DOD and NASA participate in the Senior

Interagency Group for Space and have, as well, a joint interdependency effort on advanced technology development. The latter activity in particular could provide a logical framework for developing appropriate safeguards, including Congressional awareness, for NASA's technology development program.

In parallel, the work of the AIAA for both NASA and DOD could provide another opportunity. Besides presenting its annual testimony on NASA's budget proposals, we have assisted NASA on request by reviewing its Five-Year Program Plan. In addition, the AIAA has been regularly helping DOD to marshall industry resources in preparing its Military Space System Technology Plan, or MSSTP, since the Plan's inception several years ago. Indeed, the MSSTP was derived at the suggestion of NASA from its own Space System Technology Plan. Our NASA members play important roles in reviewing the MSSTP, and initiatives have come from NASA since the inception of the MSSTP to coordinate it formally with NASA's Plan. In light of the broad scope and intensity of the SDI program, we suggest that the time for that formal coordination has come. We believe that because of the AIAA's unique background and experience in this area, we can contribute effectively to the coordination process. We offer to do so. Furthermore, we recommend that at least a correlation, if not a coordination, of the two plans be given to the National Commission on Space for their consideration. Again, we offer to help in any way we can.

Space Commercialization

We would now like to turn to four areas of NASA's budget that we see as being closely interrelated, namely, Commercial Use of Space, the Materials Processing in Space Program, the Communications Program, and the Technology Utilization Program.

We are pleased to see in last year's appropriation the request by Congress that NASA add a budget category for the Commercial Use of Space. This is certainly a timely inclusion, consistent with AIAA recommendations, and one that gives the explicit attention needed in this area. Free enterprise is basic to the fiber of our society, and space is a new domain in which free enterprise and, along with it, the future of our society have already begun to flourish. The growth of the communications satellite industry to date is a case in point.

NASA should be given the resources needed to foster the further commercialization of space, not only in space transportation and communications but also in such areas as earth observation and materials processing in space. In the last area particularly, it is vitally important to keep in mind the life-saving potential of high-purity pharmaceuticals that can be manufactured in the gravity-free environment of orbital flights. This potential is easily as meaningful for the near-term benefit of all mankind as any ultimate benefit foreseen from the human presence in space. Here, we believe, is an excellent example of a future option in space that we must not only preserve but vigorously pursue. We are therefore pleased to see a proposed increase of 26 percent over last year's budget for this important program.

In a similar vein, Congressional support last year for the full-scale ACTS Program ensured the continued growth of the communications industry across the board and helped to preserve continued U.S. leadership in the field. In terms of broadening our national technological base, it is important to continue the advance that the ACTS Program presents. It would be regrettable to diminish the momentum now established in the program, particularly in view of the wide range of contractors involved and the fact that to date over 40 organizations, including DOD, have requested consideration for experimental opportunities on ACTS.

As we have pointed out, federal investments in satellite communications have already yielded appreciable benefits to the commercial sector. Such benefits not only fall out naturally from programs like ACTS and Materials Processing in Space, they also demonstrate the value of NASA's Technology Utilization Program. We think it important that this program continue to be vigorously supported, particularly in light of a recent recommendation of the President's Commission on Industrial Competitiveness that the government should establish means to channel the technological advances it develops to industry more rapidly than at present. Clearly, NASA's Technology Utilization Program has played a key role in transferring technology to the private sector.

AIAA has had direct experience in working with NASA in its outreach program to transfer technology to non-aerospace companies. In order to acquaint the companies with NASA-developed technology and sharpen their awareness of opportunities in space, we have organized 21 seminars at NASA centers throughout the country. A total of 160 large corporations have sent over 600 key scientists and engineers to these meetings. Contacts made there have resulted in such activities as the McDonnell Douglas/Johnson and Johnson effort to develop pharmaceutical manufacturing in space, the John Deere Company's program with metal-alloy production, and 3M Corporation's recent experiments with production of adhesives and films. We believe these activities are excellent starts, but we wish to caution you that because this is a new field of endeavor, high costs, many unknowns, and long periods of experimentation confront these new industrial pioneers before products begin to flow from space to earth. Therefore, you must be patient and expect that your continued support over an extended period will be required.

International Cooperation

We applaud the current thrust of Congress and the Administration toward a greater level of cooperation in space between the U.S. and the U.S.S.R. The AIAA, in its role as head of the U.S. delegation to the International Astronautical Federation, is in favor of expanding the scope of such joint ventures and has been exploring possible activities with its Soviet counterpart, the U.S.S.R. Academy of Sciences. The preparatory work in the near term typically would include joint sessions to: (1) enhance our capabilities for space safety and rescue; (2) control the mounting problems of man-made space debris; (3) establish a world-wide space tracking and data acquisition network; (4) extend the demonstrated durability of humans in orbit; and (5) consider a joint exploratory mission to Mars, perhaps twenty years or so from now.

Obviously, much detailed long-range planning is required, planning that should form a major part of the findings of the National Commission on Space. NASA, which is charged by congress with promoting international cooperation in space, should be given every fiscal incentive to carry out its charter at a time when, as never before, such cooperation in space is needed to help promote peace on earth.

Educational Concerns

If the development of our technological resources for space is important, then so is the development of our human resources. Specifically, we see the need for a basic improvement in the education of future generations of U.S. space system engineers. It is highly desirable that they be taught what it takes by way of skills and perspective to conceive, design, build, and orbit a useful space system on time and within budget. Industry and government have known for years that the understanding and perceptions involved are basic to the successful management of space system programs. Yet only within the last few years has such an overview begun to be taught in a few engineering schools. Rather than leave these fundamental elements of our young engineers' training to their first employers and the random circumstances of their early years, we believe they should begin as a regular part of their academic curricula. Aside from giving a more focused influence to their career paths, we see this as benefitting the nation by greatly improving their productivity. We in the AIAA have been taking steps toward this end, and we appreciate the active support we have been receiving from academe. We commend NASA for its initiative in that regard as well and recommend the funding in this area be sustained.

In conclusion, Mr. Chairman, the AIAA recommends that Congress approve at minimum the funding level proposed for NASA in FY 86. In particular, we recommend that Congress pursue an investment strategy that safeguards our investment in space. Such a strategy should emphasize these six basic areas:

- Effective preparation for a permanent manned presence in space
- Achieving a mature, cost-effective space transportation system
- Planning of new options and opportunities
- Advanced space technology development
- International cooperation in space
- Enhanced education in space system engineering

Mr. Chairman, that concludes our remarks. Once again, we are grateful for the opportunity to be here. We would be pleased to answer any questions that you may have.

Mr. **Nelson**. Thank you, Dr. McLucas.

Mr. Robinson, we're pleased to hear from you.

Mr. **Robinson**. Are we on?

Mr. **Nelson**. Yes.

Mr. **Robinson**. Thank you, Mr. Chairman, and I want to say first, again, thanks for the opportunity for letting me testify on behalf of the American Society of Mechanical Engineers. We've got about 100,000 members, of which 20,000 are involved somewhat in the aerospace industry.

First of all, I would like to say, as far as NASA programs, we're proud of NASA's performance in space and we're really honored to support the NASA budget process in these times with tightly constrained budgets.

In general, we're pleased with the overall budget authorization this year, but I'd like to comment a little bit further on that separately. We feel the Nation will benefit greatly from the space station and microgravity material experiments and that that is vital to getting a base established for the space station.

Concerning the OTA civilian space station and issues of the future, we're pleased to see that OTA is concerned about the long-term roles of the U.S. Government and civilian sectors in space and we emphasized the need for a definitive national space policy in our testimony a couple of years ago in March 1983, and we feel the need is even more important today as we move toward an industrial revolution in space.

We're pleased to see the formation of the National Commission on Space to assist the United States in defining and articulating the long-range goals and needs of the Nation's civilian space program. The OTA study is a valuable contribution in the necessary planning process and we believe that long- and short-term objectives should be addressed in the planning process. We feel that both a 5-year definitive plan and an overall 15-year plan are essential and that an industry/Government team should be involved in that planning activity, particularly with the establishment of the base and the various options that are going tc be available to us.

We feel the plan should keep our options open for both long- and short-term objectives, such as the orbiter production line. Once it's shut down, as we all know, it's going to be effectively lost to supporting additional requirements. Short-term objectives, such as the activities that could influence the shutdown of a production line, we think should be assessed, maybe on a quarterly basis, with some industry involvement to a NASA committee in terms of the planning that this Commission would go forward with.

We feel that technical input from industry is essential to ensure the desired options remain open in these areas. We feel an overall plan should be dedicated to line items and support elements should be included that involve the expendable launch vehicles, the STS, space station and infrastructure, if that would be more appropriately called, and the other elements, the OMV and the OTV, but they are all important elements in the overall concept and must be addressed.

We feel the plan should involve procedures for commercialization, particularly with eventual management by industry, but that should be established when the time is proper for industry and to move in and take over certain aspects.

NASA served the Nation well and there are certain objectives that we feel are compelling in terms of getting the space station in place now. It's definitely the investment for the future for the United States. We feel that the follow-on, like resupply applications, will effectively reduce development costs. These things should be evaluated in the planning in terms of cutting down production costs on future systems and, from a space perspective, perhaps with people in space, the objectives and planning can be better implemented.

We feel that an early base is essential regardless of the period of entry in terms of planning. In other words, we should go forward with the space station, have the space station in place within the decade and not delay funding that would prohibit that or extend the schedules.

We share the OTA's concern about major line items being dropped or slashed and cost overrun relative to other programs where costs are short-funded in certain areas. We've seen disastrous effects of start/stop programs in the past.

We feel that the budget is somewhat stagnated with less than 1 percent of the total budget going to NASA that we felt and recommended that the more appropriate budget line would be in the order of 1.5 percent, which means more investment in the areas where the return is high, such as the communications industry, which is a multibillion-dollar return per year.

With regard to the space infrastructure, we believe that an annual investment of three billion over a 15-year period to be the most productive of the alternatives that they presented in their study and a commitment of one billion annually would have to be considered an absolute minimum. We place the highest priority on the development of the space station as a planned stepping stone to lunar presence or to a manned Mars mission.

There's a strong need for automated activities and we feel that in conjunction with the space station and the orbital transfer vehicle, orbital maneuvering vehicle, the high priority should be placed on automated activities. In our statement, we summarized the primary goals established by OTA and we rated those, which may be reviewed.

One area that we felt was probably the least important that was discussed today from a viewpoint of just taking people into space would be somewhat frivolous in itself. On the other hand, the right cross-section of people would have a desirable variety of perspectives from space which would make a major contribution to future planning, planning with a space perspective and an extended space culture.

The decision to acquire the space station, we feel, is correct. It will provide new technology that's needed and it'll provide the base for the future U.S. space program. Our task force felt that the space station should be the centerpiece of the U.S. space program, especially as we proceed into an era where working and living in space becomes commonplace.

We believe this will increase the eventual cost of the space station, which will slip deployment if the funding of $50 million that has been taken away is not reinstated. So we did make recommendations, not only on the space station, but in other areas to reinstate the overall funding that was initially recommended by NASA.

What I'd like to—just briefly state the recommendations that we had out of our review of the OTA and the NASA budget. The No. 1: We felt the orbiting maneuvering vehicle should be funded at a level to meet a deployment date in 1990, and that the development of the orbit transfer vehicle should also be continued with a start date in 1993 to 1994 timeframe.

Also, that Congress and the National Science Foundation should continue to determine ways and means to alleviate staff shortages in the nation's engineering schools. Congress should also study, perhaps, and ensure the nature of engineering employment levels caused by the boom/bust of some Government funding influences.

Congress should study and develop a plan for commercialization of space technology. We feel the United States should be continually developing and advancing the state of the art in communications satellites if we hope to remain competitive in the field. The advanced communication technology satellite is a good example where we should be headed.

Both long- and short-term planning should continue to consider the utility of expendable launch vehicles, including shuttle derived vehicles where unmanned cost-effective approaches may exist.

That concludes my statement, sir.

[The prepared statement of Dr. Robinson follows:]

Comments on

National Aeronautics & Space Administration
FY 1986
Budget Request

Submitted to:
Subcommittee on Space Science and Applications
Committee on Science and Technology
U.S. House of Representatives
March 26, 1985

Prepared by the Task Force
on Civilian Space Policy
Aerospace Division

The American Society of
Mechanical Engineers

Introduction

Mr. Chairman, my name is John Robinson and I am Chairman of the Task Force on Civilian Space Policy of the American Society of Mechanical Engineers' (ASME) Aerospace Division. We are pleased to have this opportunity to present our views to this Subcommittee and we thank you for allowing us to appear before you today. This statement represents the considered judgement of the Task Force, a group of experts in the field, rather than an official position of ASME.

ASME is a non-profit, educational, scientific and charitable society founded over 100 years ago. Membership in ASME exceeds 110,000 members who are mechanical engineers and students. Because of the variety of applications of mechanical engineering, about 20 percent of our membership is directly involved in the aerospace industry. Many more are involved as second or third tier contractors.

Traditionally we prefer to comment on technical issues, and we will confine most of our comments to selected programmatic aspects of the proposed FY-86 budget of the National Aeronautics and Space Administration (NASA). However, we are also vitally concerned with engineering manpower issues as they affect the aerospace industry and that industry's ability to meet NASA's goals.

In general, we are pleased with the funding levels proposed for the FY-86 budget, especially considering the severe Government budget deficit. We are aware of the pressures being leveled upon you and the Administration to cut Government costs dramatically. In this regard, we would like to focus our comments on specific NASA programs which we feel require special attention. This selection does not mean, however, that the programs which we do not address are not important - all of the NASA programs, as delineated in their FY-86 budget submittal, have merit.

Office of Technology Assessment (OTA) Space Station Study

As you requested, Mr. Chairman, the ASME Task Force has reviewed the recommendations of the Office of Technology Assessment's (OTA) Space Station Study.

Although some of the comments in our written submittal touch upon items in the OTA study, we will specifically address the study at this point.

We were very pleased to see that OTA is concerned about the long term roles of the U.S. Government and civilian sector in space. We emphasized the need for a definitive national space policy in testimony presented before this Subcommittee in March of 1983, and feel the need is even more important today as we move towards an industrial revolution in space. Without a well understood and publicly supported policy, economic and political pressures may cause some to think that we should "spend our money solving the problems here on earth and not in space." This, however, is short-sighted and fallacious thinking. The foundation for much of today's economic prosperity is the result of technology developed in our space program. Every aspect of our national economy, from agriculture to communications, from manufacturing to medicine has benefited from our investment in NASA and the space program.

These fantastic advances and contributions to our national well being have been possible because of a combined national effort that evolved from the dedication of NASA, the affected branches of the Defense Department and the ingenuity of our engineers and scientists. Underlying all of these advances is a clear inference of a national policy; however, there are indications that this national policy is not well understood, and is not uniformly followed.

In this regard, we are very pleased to see the formation of the National Commission on Space to assist the United States in defining and articulating the long range goals and needs of the nation's civilian space program. The OTA study is a valuable contribution to this necessary planning process.

We feel that both a five year detailed definitive plan and a fifteen year overall plan are necessary to coordinate planned growth of ongoing programs of importance. These plans should be updated annually by a joint industry/government team that can provide necessary guidance regarding program direction and future growth. These plans should keep our options open for both long term objectives such as moon and Mars visitation and short term objectives such as the fifth orbiter. In addition, we feel short term objectives should be reviewed quarterly to assess their status so that on-going activities can be planned and controlled effectively. Industry input is essential at this stage to insure that the the top level policy decisions of NASA management are comprehensive and technically sound.

We feel the overall plan should have dedicated line items addressing major space system support elements including expendable launch vehicles; the space transportation system and the space station; space science and applications including a continuing sensible planetary program; commercial programs and technology utilization; and space research and technology.

Further, we feel that a major line item should not be dropped or slashed in order to support a cost overrun in another important program. We have seen the disastrous effect that such start-stop funding interruptions have had on other important programs in the past, such as unmanned planetary exploration. Major aerospace programs usually require ten years to evolve. On the other hand, private enterprise looks to the short term return on its investment. This creates the need for continued NASA participation in keeping major programs on line.

Although the interests of the U.S. should be paramount, we feel there is room and need for international cooperation. In the case of the space station perhaps a dedicated docking module for future foreign trade and commercial interchange should be mandated in the design. The interests of private industry should also be considered in the planning process.

We agree that additional study is required to assess international cooperation and long-term national budget commitments as we consider our future in space. And we of course must address the financial and technical risks involved before we proceed. The public should be made aware of the shortcomings of allocating only approximately .8 of one percent of the national budget to NASA. We feel a NASA base budget of 1.5% of the total Federal budget, as we saw in the early 70's, is more consistent with current needs. The FY 1986 budget shows an undesirable stagnation in program activities at a time when growth and investment in these areas is crucial. We continually talk quality, efficiency and productivity—however our plans and budgets do not effectively reflect these ideals.

With regard to space infrastructure, we believe an annual investment of $3 billion over a fifteen year period to be the most productive of the alternatives listed in table 3 of the OTA report. A commitment of $1 billion annually would have to be considered the absolute minimum. We place the highest priority on the development of the space station as a planned stepping stone to a lunar presence or a manned Mars mission.

There is also a strong need for automated activities in conjunction with the space station and the Orbital Manuevering Vehicle (OMV). We visualize the expansion of robotics in space in conjunction with the new manufacturing processes which must be developed for space factories to become a reality in the future. However, a manned presence will be necessary in order to monitor and service these robots and processes.

With regard to the goals suggested by OTA, we feel that most of them are supportable. In fact, only Goal 5, the transporting of hundreds of people into space, seems frivolous. To summarize, we have ranked the OTA goals as follows:

1. Establish a global information systems service regarding natural hazards—high priority.
2. Conduct medical research of direct interest to the general public—high priority.
3. Establish a global, direct, audio broadcasting, common user system service—high priority.
4. Reduce the unit cost of space transportation and space activities—high priority.

5. Increase space-related private sector sales--high priority.

6. Use space probes to obtain information relative to Mars and some asteroids prior to early human exploration--medium priority.

7. Make essentially all data generated by civilian satellites and spacecraft directly available to the general public--medium priority.

8. Exploit radio/optical free space electromagnetic propagation for long distance energy distribution--medium priority.

9. Establish lower cost reusable transportation service to the moon and establish human presence there--low/medium priority.

10. Transport hundreds of citizens per year into space for short visits--lowest priority.

In conclusion, we would like to touch again upon what we see as a lack of objectives addressing efficiency and productivity. We recommend the following:

1. That the development of robotics, necessary for the space factories of the future, be considered a high national priority.

2. That satellites to facilitate computer to computer communications be launched in an effort to improve national productivity.

3. That Congress study and develop a plan for the commercialization of space.

Space Station Funding in the FY 1986 Budget

The Task Force considers the space station to be the centerpiece of the U.S. space program, especially as we proceed into an era where working and living in space becomes commonplace. We are looking forward to the promise of new products from the microgravity (weightless) environment found in space. The mechanical engineer looks with great anticipation to efforts to produce new hi-tech materials as well as lighter and stronger forms of basic materials such as cast iron. Our colleagues in aerospace companies are already working with the pharmaceutical industry to produce new medicines in space. There is also the promise of new semiconductor crystals, produced in space, which may lead to more miracles in that field.

We noted in the FY-86 NASA budget that funding for the space station was $50 million less than anticipated. We believe this will increase the eventual cost of the space station and will slip the deployment schedule to late 1993 or early 1994. While we recognize the current budget pressures, we feel the space station will play a critical role, similar to the Apollo and space shuttle programs before it, in the development of technology. This thrust will set a technical direction for the country into the 1990s and it is important that we pursue the program vigorously. We recommend, therefore, that the budget for the space station be increased from $230M to the original NASA request of $280M.

Although we look forward to the industrial potential of making products in space, there are still many barriers that must be overcome to make significant advances in microgravity processing. We feel that NASA is not developing a scientific base of knowledge rapidly enough to permit commercialization. Likewise, there are major financial and technical risks to making products in space. Therefore, we recommend that the following changes to the FY-86 budget be made to enhance the potential that space may offer our non-aerospace industries, and lay a solid foundation for scientific and commercial users when a space station laboratory is available in the mid 1990s.

* Increase the Materials Processing in Space budget from $34M to $40M to support more scientific experiments, assure shuttle micro-gravity flight time, and spur development of a science data base for commercial application.

* Increase the Commercial Use of Space budget from $30M to $50M. This is needed to expand the outreach program and to build essential research and development equipment (furnaces, biological and genetic separators, etc.) so that scientists may, with minimum risk, perform basic experiments to prove their feasibility prior to entering a costly development program.

* Increase the Space Shuttle Payload Operations & Support Equipment budget from $63.9M to $73.9M to support more materials processing experiments and to initiate the development of auxiliary power systems for microgravity research and processing aboard the space shuttle. The shuttle, acting as a laboratory, is needed to accommodate users in the late 80s and early 90s prior to launch of the space station.

These recommended budget increases for microgravity material processing and related programs total $36M in FY-86 and we suggest further increases be considered in future years. This program lays the foundation for the future of space into the 21st century.

The space station program is our greatest hope for producing technology and products in space that will spur our national technological revolution. The time is now to move forward and secure that future.

Upper Stage Development

During the past year, we have seen the repair of the Solar Max satellite in orbit by the crew of the orbiter. In addition, we witnessed the retrieval and return to earth of the Westar 6 and Palapa 2 satellites from low earth orbit. With these successes, it is obvious that the development of a capability to exploit the cost savings which may be realized by retrieving satellites from higher orbits and returning them to low earth orbit, where the shuttle can bring them aboard, must be further developed.

In light of this, we were pleased to see NASA initiate the Orbital Maneuvering Vehicle (OMV) which will enhance both the shuttle and space station's capabilities. The OMV will provide the capability for on-orbit retrieval of satellites and platforms up to 1500 miles from the orbiter and space station. It will allow servicing, maintenance, and refueling of satellites at the shuttle, the space station or in the particular satellite orbit if a satellite service kit and appropriate propellant resupply module is developed. Knowledge gained from this program will also assist in the design of the future platforms and satellites to facilitate their servicing and/or updating. It will also provide useful data for the design of the Orbital Transfer Vehicle (OTV).

We continue to believe that a versatile upper stage vehicle (reusable cyrogenic OTV, probably aero assisted) will be required to adequately service large geosynchronous orbit (GEO) platforms in conjunction with the OMV. However, we question NASA's current plans to initially ground base the system with a transition to space basing. In the current austere funding environment it would seem less costly and more efficient to space base initially. Space basing would reduce the systems' costs and would serve until the space station is able to develop a suitable on-orbit OTV hanger and maintenance facility, around the year 2000. This would indicate an OTV start in the 1993-94 time period when funding would not be as severely impacted by space station funding requirements. In the meantime, continued systems and technology studies and demonstrations should be carried out to define the optimum OTV system. Requirements for both unmanned servicing of satellites and platforms, as well as manned servicing in GEO, should be explored. We also believe that a building block approach should be incorporated into the OTV design to allow for eventual lunar and Mars operations. Finally, we believe that a new generation of manned maneuvering unit should be developed along with the remotely operated OMV to take full advantage of man's utility in space.

On-Orbit Servicing

During the transition period prior to on-orbit satellite servicing, we believe that the U.S. Government, as well as commercial satellite developers should be encouraged, if not mandated, to provide on-orbit refueling and/or servicing standard interfaces as soon as is practical.

We believe that NASA's projected new start (1987) for an in-bay hydrazine tanker together with the recent on-orbit refueling and servicing demonstration on the shuttle will go a long way toward insuring the viability of on-orbit refueling. Further demonstrations of on-orbit servicing operations and module replacement are needed before users will commit to the necessary satellite modifications or development of multi-functional or multi-service operational platforms, particularly in GEO.

Fifth Orbiter

We are disappointed at the trends we see in developing an adequate fleet of shuttles to serve NASA, the Department of Defense (DoD), and other U.S. Government, commercial and foreign customers. While the demand for shuttle launches has not developed as rapidly as planned, there is no assurance that it will not increase in the next 10-15 years. We applaud the Reagan administration's decision to have NASA and the Air Force begin studying the cost and design of the "second generation" shuttle which will be capable of carrying heavier payloads into higher and more diversified orbits. However, these new vehicles will not be operational until the end of the century and we must rely on our current fleet of four orbiters until then.

While we agree with the DoD decision that a back-up Expendable Launch Vehicle (ELV) capability should be retained, we believe that the country is not being well served by limiting the orbiter fleet to four vehicles. The U.S. now possesses the world's most versatile launch vehicle and on-orbit laboratory, a capability that no other country possesses and will not for some time. We should not let this advantage slip from our grasp as we have done in other areas such as earth observation. We believe at least one additional orbiter should be procured and an extended duration capability added to allow micro-gravity research in orbits other than that of the space station. Considering that the fixed costs have already been incurred for everything except the 5th orbiter, its introduction will result in increased flight capacity with the benefit of reducing the cost per flight of the entire Space Transportation System (STS). In addition, we believe that future requirements for space station transportation, Strategic Defense Initiative demonstrations, and the other needs of NASA, DoD, and commercial space users mandate the construction of the 5th shuttle.

We understand that the procurement of spare parts is currently keeping the shuttle assembly line in operation. However, once an assembly line as complicated as the orbiter's is shut down, it will be virtually impossible and prohibitively expensive to reopen it whether to build more spare parts or another shuttle. In conclusion, we believe funding should be provided in the FY 1986 budget for development of the 5th shuttle and we hope Congress will correct this deficiency.

Expendable Launch Vehicles (ELV)

During the past few years there has been considerable controversy concerning ELVs and the possible conflict with the orbiter fleet. We feel the ELV has served the nation well over the last quarter-century and will continue to do so in special applications through the next quarter-century. Both long and short term planning should continue to consider ELV utility, including shuttle derived vehicles, where unmanned cost effective approaches may exist. We believe that the ELV family of vehicles and launch services can soon be turned over to private industry. However, shuttle derived vehicle activities, currently being studied, should continue under NASA management guidance in conjunction with development of a second generation shuttle.

Shuttle Pricing

We note the controversy surrounding shuttle pricing in the post 1988 time period. We question whether full cost shuttle pricing is in the best interests of the Nation. There have been many precedents which indicate the wisdom of Government providing special incentives to open up "new frontiers." Special price breaks for commercial space entrepreneurs are required if we are to fully realize the commercial space potential in any realistic timeframe. To date only satellite communications have demonstrated any semblance of commercial viability. However, many other space applications, services and products, have this potential and must be encouraged. To not do so lacks foresight. Even with marginal shuttle pricing (costs added to the Government's costs), prices could be lowered to the $30-40 M/flight range without actual loss to the Government. Even prices below the marginal costs could be justified in cases where payloads have extremely high commercial potential if the process or product can be proven or demonstrated.

Advanced Communications Technology Satellite

We were especially pleased to note the inclusion of the Congressionally-mandated Advanced Communications Technology Satellite (ACTS) in the NASA budget. Over the past few years, we have noted an increase in the development of foreign satellites, and the launching of these satellites, as well as satellites manufactured in this country, on the competing European launch system, Ariane. In light of this development it is important for the United States to be continually developing and advancing the state of the art of communication satellites if we hope to remain competitive in this field. NASA must take the responsibility for new advancements in communication satellites, since the private sector has, to date, failed to capitalize on this opportunity following the commercialization of this segment of the space program some years ago.

Manpower

This subject has been addressed on several occasions by members and officers of ASME. The major problem is that the demand for engineers has raised salaries to such a degree that colleges and universities cannot afford to meet the high salaries that industry pays. The result is that engineering programs in many schools are impacted, impacted in the sense that there are too few professors and facilities to meet the large number of students who are qualified and want to enroll in the program.

Since the late 1960's, the aerospace industry has experienced a number of manpower retrenchments which have resulted in critical manpower age gaps in the engineering and science industry work force. If present trends continue, sometime in the near future, there will not be sufficient numbers of experienced engineers to meet NASA's programmatic goals. This statement holds true for the defense segment of the aerospace industry as well.

Congress should study the problem of engineering employment cycles caused by government funding and evaluate methods to maintain a more steady employment level. Congress must begin to project 5 year plans for the Defense Department and NASA to minimize the boom/bust effect of Government funding on engineering employment.

Summary

The ASME Task Force supports the NASA budget and is generally pleased with the proposed plans put forward by NASA. We feel the nation will greatly benefit from the space station and microgravity material processing and have proposed supplemental funding for these programs. We are very fearful that there will be an aerospace industry engineering leadership and expertise problem in the next 5 to 15 years as the 50 plus-year old age group of engineers retire and the next age bracket of experienced aerospace engineers will be in their late 30's. This will leave a critical gap in experienced engineering manpower.

RECOMMENDATIONS

1) The Space Station program should be augmented with additional funds to allow for deployment in 1992.

*Space Station systems definition & technology: $50M

*Microgravity Material Processing: $36M

-Material Processing in Space: $6M

-Commercial Use of Space: $20M

-Payload Operations & Support Equipment: $10M

2) The Orbital Maneuvering Vehicle should be funded at a level to meet a deployment date of 1990.

3) Congress should consider the timeliness of starting fabrication of a 5th orbiter or assure that our options remain open to do so in the immediate future.

4) Congress and the National Science Foundation should continue to determine ways and means to alleviate staff shortages in the Nation's engineering schools. Congress should also study the mercurial nature of engineering employment levels caused by the "boom/bust" effect of government funding.

5) Congress and the President should work together to create a bi-partisan Space Policy which will challenge the Nation to achieve even greater accomplishments in space. The Space Policy should include definitized 5-year and projected 15-year plans.

6) Congress should study and develop a plan for the commercialization of space technology.

This concludes my prepared statement Mr. Chairman. I would be happy to respond to any questions you may have at this time.

Acknowledgments

Members of the ASME Aerospace Division Task Force on Civilian Space Policy which developed this statement are:

Mr. John W. Robinson, Task Force Chairman
Vice Chairman, Board on Government Relations
Former Chairman, ASME Aerospace Division

Mr. Walter C. Glowski; Chairman, ASME Aerospace Division

Mr. Louis Hemmerdinger, P.E.; Former Chairman, ASME Long Island Section
Former Chairman, College Relations, Region 2

Mr. Phillip J. Legendre, P.E.; Chairman, ASME California Inland Section
Public Affairs Chairman, ASME Aerospace Division

Mr Donald J. Simkin; Member, ASME Aerospace Division

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Mr. Nelson. Thank you, Mr. Robinson.

Dr. Wilson.

Dr. Wilson. Yes, thank you, Mr. Chairman, members of the committee.

First of all, we apologize for Ben Bova, our president, who was unable to be here today. His statement has been submitted to you.

Mr. Nelson. All of the statements of all the witnesses today will be included.

Dr. Wilson. I'll just touch on a couple of points that I think are important here.

First of all, the National Space Institute differs from all the other groups that you see here today in that they represent professionals who make their living in the aerospace business one way or another. The National Space Institute is a publicly supported organization and while we have many professionals in our Institute, only about 15 percent, we surmise, are really directly involved in it, so we truly are a citizen's group supporting this program.

I find very little to disagree with Drs. Drews, McLucas and Robinson. Everything they said sounds pretty good to us and we could support that. I think that many of the points that were made in the OTA report were soured by the way it was treated in the press and the—which they brought on themselves with some highly gratuitous comparisons in the opening parts of that report. They were unnecessary and tended to diminish the positive aspects of that report.

The other issues I'd like to speak briefly to is that we really need—while we're talking about space station development and so forth, we need to think of space and our expenditures in space as long-term investments and there've been many studies made through the years about the time period between when something started and when it began to have a payoff.

The most famous story there is the one about Farraday who was asked by the Queen what is this electric motor good for? He said, "Well, it's just a baby; it'll grow," or something to that effect. The point is that many of the things that are happening now will—the impact, the return from them will simply not be felt for many years, and always have to keep that in mind when you're talking about the kinds of money that you're spending now on the space station.

I rather think that in 20 years from now, perhaps longer, perhaps sooner, when one really looks at what has happened to the space station and what benefits have come out of that, probably not a single person today has come up with the thing which will have turned out to be the most important reason why we put it there. We are simply not smart enough to predict all of the things that will come of this. What we are smart enough to know, or should be smart enough to know, is that unless we provide the mechanisms for these things to happen, then they will never happen.

So the NSI supports very strongly the development of the space station, call it what you will. It is simply the next step in space that we must take.

About the shuttle fifth orbiter, I think it's no secret that we, as a nation, are skating on extremely thin ice with the current fleet of orbiters. If anything happens to any one of those, we are in deep trouble and I think that that's an issue that needs to be continued to be followed by the subcommittee and the Members of the Congress.

The pricing, the shuttle pricing policy is a really difficult one because it costs a lot of money to put a shuttle into orbit now, and at least one of the reasons it costs so much money is that we didn't put sufficient money into shuttle development in the first instance, back in the 1970s. The—there is a clear chicken-and-egg problem here. If you raise the price up to where it's going to be to cover the full cost for it, you're simply going to run all your customers off. You can't pay that kind of money, and we're competing with nations like France, with Ariane, where they don't care what they charge you for that vehicle. They're going to undercut us every way they can as a matter of national pride, so it's—there're simply—the equations for writing costs are not the ones that you sit down with a slide rule and a machine, adding machine of some kind, to figure out all the dollars and all the pounds and all that. That simply is not the way you can do this because you have these other considerations in mind.

If we lower the price on the shuttle, then the—I'm quite sure the French will lower the price on the Ariane and—so that it's really difficult to come up with a rational pricing policy because there're so many other considerations.

Finally, on the Commission, the Space Commission, we support that. We think it's something that needs to be done. It certainly is good once in a while for the country to take a look at this from this kind of a basis. Unfortunately, the history of the impact of these kinds of commissions is not particularly good, although some commissions in the past, such as the Hoover Commission of the early 1950s, tended to have some kind of an impact. We hope—we would hope that this commission and its results would produce better results than, let's say, the Agnew Space Commission of 1969.

On man-tended versus manned, I think it's not productive to put the space program in a conflict situation of this versus that, manned versus unmanned. It's—I know those distinctions have been battled over for 25 years, but to me, they are not productive. We do certain things that we have to do with unmanned missions, such as the ones to Saturn and the outer planets. Clearly we're not capable of sending men out there yet, but there are other factors, other operations which simply are better done with humans in presence—in the situations.

So we think that manned versus—man-tended versus manned is really a—is not a good way to look at it. You look at what the job is that you want to do and in some cases, it is going to be more efficient to use a man-tended operation, and in some cases, it is going to be more efficient to do the other.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Bova follows:]

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

Statement by:
Ben Bova
President, National Space Institute
26 March 1985

Mr. Chairman and Distinguished Members of the Subcommittee:

I am highly gratified to be able to present the views of the National Space Institute's 10,000 members to you this morning.

The National Space Institute is the oldest, and one of the largest, grass-roots citizen's organizations working for a stronger and more effective American civilian space program. Our members come from all walks of life, from all sections of the nation, from every shading of the political spectrum. They include business executives and students, television celebrities and astronauts, members of the Congress, housewives, distinguished scientists and writers.

We regularly poll our members to find out which goals they believe the space program should be aiming for. In addition, we have conducted larger surveys of broader groups of citizens, in conjunction with national magazines. We feel that the results of these polls and surveys give a clear picture of the desires of a significant, informed cross-section of American voters.

Overwhelmingly, these polls show that the informed public strongly supports the program to place a permanent, manned space station in orbit. (Details of the poll results are appended to this statement.) Moreover, our respondents also support continued vigorous exploration of the solar system, such as the Pioneer, Voyager and Mariner programs and the planned Galileo mission to Jupiter.

Frankly, the National Space Institute's members are highly disappointed that there is no American spacecraft on its way to rendezvous with Halley's Comet. That was an opportunity for scientific advance and national prestige that we mistakenly threw away.

As you consider the Fiscal Year 1986 proposals, it might be helpful to raise your sights beyond the immediate problems and take a deeper view of the opportunities that space technology offers for the longer-range future.

Space is a long-term investment. For example, the technology developed in the 1960s for the Apollo program has helped to fuel the electronics industry boom of the 1980s. The industrial experiments being carried out today aboard the space shuttle will lead to full-scale manufacturing facilities in orbit, once the space station begins operations. The economic well-being of the United States depends critically on the development of high technology, and space is the whetstone on which we sharpen our highest technological skills.

The space station is indispensable. No factory on Earth can be profitable if it works only one week out of four. Neither can industrial and pharmaceutical manufacturing be profitable if they are restricted to operating on the shuttle. The space station will allow today's experiments in zero-gravity processing to grow into profitable full-time industries.

Much has been argued about the relative merits of a permanently manned space station vs. an unmanned or man-tended station. Most of the opposition to a permanently manned station has come from scientists who fear that manned space programs take money away from their own favorite projects. In my view, such criticism is narrow-minded and self-serving. When one of these scientists automates his own laboratory, here on Earth, so that it can operate for months at a time without a human being on the scene, then I'll believe we can build an effective unmanned space station.

To assure that commercial and industrial organizations have reliable, efficient, and cost-effective access to space, it is important to create a pricing policy for the space shuttle that, on the one hand, encourages continued development of space industries, yet on the other hand does not compete unfairly with the private companies which are developing expendable boosters for commercial use. This is a difficult problem, but any decision on pricing policy for the shuttle must consider both these aspects.

The space sciences must not be neglected. We have barely begun the exploration of the solar system, and there is much to be learned. The Space Telescope, the Galileo program. the Venus Radar Mapper -- these and other space science efforts provide the new knowledge that inevitably leads to powerful new capabilities for humankind.

In summary, to date the space program has been the best investment the American taxpayer has ever made -- with the possible exception of the Louisiana Purchase. We are now beginning to reap the economic benefits of the investment we made two decades ago. It would be utterly foolish if we failed to re-invest some of the profits we have made, so that we can assure continued economic, technological, and scientific gains into the 1990s and beyond.

For Release March 26, 1985

Addendum to Statement by:
Ben Bova
President, National Space Institute
before the
Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Results of the National Space Institute Space Opinion Survey (Conducted November, 1984)

The National Space Institute has approximately 10,000 members whose average length of membership is almost 4 years. Their average age is 34 years (range 9-90) and average annual income is in excess of $32,000. They come from every state in the union, Puerto Rico, the Virgin Islands and 24 foreign countries. Eighty four percent have had some college or above with nearly 30% having some post graduate education.

While the membership is mostly technical (28%) and professional (44%), a broad spectrum of occupations is represented with only about 15% directly involved in the space program (15% non-technical and 13% students make up the rest). About 47% own their own computers and an impressive 98% say that they have had a lifelong interest in space exploration.

NSI's highly educated membership is also politically active, 86% voted in the last presidential election (of the remainder, 8% did not vote, 4% were too young and 2% were not U.S. citizens). All shades of political opinion are represented with the balance being slightly conservative although not as conservative as a recent Gallup poll of the U.S. population. The numbers are: liberal- NSI 19%, Gallup 18%; moderate- NSI 57%, Gallup 46%; conservative- NSI 24%, Gallup 36%. Nevertheless,

NSI Space Opinion Survey(continued)

NSI members voted more heavily for President Reagan than the general population: Reagan 66%, Mondale 29%, others 5%.

As one might suspect, NSI members strongly support the U.S. space program, but their support is not narrow and overwhelmingly favors both manned and unmanned projects for space exploration. Members support greater expenditures for NASA for which they would be willing to be taxed an additional $50 per year. They clearly believe that spending on civilian space projects has a significant positive effect on the nation's technological and economic health. They support the commercialization of space, establishment of a moon base by the year 2000, a manned mission to Mars, early development of the space station, and greater international cooperation including another cooperative space project with the Soviet Union. By a slight margin they approve of continued development of an antisatellite weapon and by a larger margin believe that the space program deserves more coverage by the major news media. In general, NSI members are way ahead of both the general public and national leadership in what they believe could and should be done by the United States in space exploration.

Given below are the statements to which each person was asked to respond, giving a level of agreement, with 0 = total disagreement, 5 = neutral, 10 = total agreement, and the average of all responses:

1. The nation should adopt an evolutionary approach to the advancement of the civilian space program, rather than adopt a major goal with a time deadline (such as a space station)................................... 5.5

NSI Space Opinion Survey(continued)

2. The planetary exploration part of the civilian space program is currently underfunded............ 8.3

3. Science fiction is a disservice to an informed public regarding the science reality of the space program... 3.3

4. The U.S. should continue development of an antisatellite weapon.................................... 6.2

5. Manned space flight is not as cost-effective as unmanned probes and satellites......................... 3.7

6. I would support an increase in my taxes on the order of $50 a year to support a stronger national civilian space effort.. 8.8

7. NASA should perform research and development activities, but leave operations such as launch systems to private industry..................................... 5.0

8. NASA should encourage industry to commercialize space by providing low-cost subsidized launch facilities.... 6.9

9. Industry should be allowed to commercialize space applications once they have been demonstrated by the government.. 8.1

10. There should be an additional annual tax of approximately $2 per working adult to be used for space research.8.2

11. The present Administration has a favorable attitude toward space exploration and development........... 6.9

12. The classified flights of the shuttle will damage the perception of America's pursuit of utilizing space for peaceful purposes.. 5.6

NSI Space Opinion Survey(continued)

13. A future U.S. space station effort should be directed toward international participation................ 7.7

14. I would support steady funding of NASA at a level of 1% of the Federal Budget............................ 8.7

15. The U.S. should establish a goal of permanent occupancy of a moon base by the year 2000.................... 8.3

16. The U.S. should undertake another cooperative space project with the Soviet Union......................... 7.1

17.The U.S. should pursue a manned mission to Mars... 8.3

18. Spending on civilian space projects has a significant positive effect on the nation's technological and economic health.. 9.2

19. It is important to establish a plan for planetary exploration based on scientific return, cost, and schedule... 8.0

20. The space program deserves more coverage by the major news media.. 8.7

21. I am likely to contact my national elected representatives on a matter of political importance to me over the next year... 6.6

22. A presidential candidate's level of support for the civilian space program is an important consideration in my voting for him.. 8.0

23. We should develop a permanent manned space station as a national goal by

1990- 42.3%, 1992- 30%, 1994- 25.1%, not at all-2.5%

Mr. **Nelson**. Thank you, Dr. Wilson.

Mr. Walker.

Mr. **Walker**. Thank you, Mr. Chairman. I understand we're limited in time, so I'll try to make my questions brief.

Dr. Wilson, just to follow up on the last point that you made, I think that that's absolutely correct, that there are—there are applications for man-tended kinds of operations, but the key question we're going to face before very long in the Congress is whether or not the habitat that we build or the space station or whatever it ends up being, the structure, as to whether or not that going to be man-tended or whether or not that is going to be permanent. It seems to me that becomes a key policy choice, then, that Congress makes if we—if we, in fact, determine that that shall not be, at least in the initial instance, a permanently manned facility.

Dr. **Wilson**. Well, if you design it to be man-tended, then you preclude the possibility of manned operations, and I think the way to approach it is from the other side. You make it so that it's man-operated first and then you discover whether or not that can be done more efficiently man-tended.

Mr. **Walker**. All right.

Dr. Drew, I was interested in your comment about being in the White House when you were trying to determine what to do after Apollo and it—you indicated that, you know, it was decided that we wanted to continue to have a manned presence in place—in space; that the shuttle was the right way to go and obviously, the shuttle was also designed in a way that we should have built a space station about the same time. I mean, we would be in a far different perspective with dealing with a lot of these questions if, in fact, we had decided at the same time to go—go ahead, but obviously there were budget constraints and so on there.

But, you know, it is an important question as we look to shuttle in my mind and I would just appreciate your comment—I mean, as we look to space station. I would appreciate your comments because the one great failing, it seems to me, out of the Apollo Program and out of the whole Manned Moon Program was the fact that there was no real follow-on to it, that we went, it was a great adventure. When it was all over, everybody said, "Wasn't it wonderful what we achieved?" It was great and some, but there was no real followthrough. I mean, it was an end in itself. We got to the Moon; we did what we said we were going to do and that was it. And beyond that, now, we've always looked back and we—we developed technology; we've gotten spinoff benefits from it, but I—I often say—I'm often questioned myself, where would we be if we had decided to follow on to that program right at that point?

My guess is that we would have a manned colony on the Moon right now. My quess is that there would have been a lot of followthrough if, in fact, it had been a part of an ongoing policy and not an end it itself.

You know, I think in defining the space station, it is important that it doesn't become an end in itself, much like Apollo became an end in itself. I'd appreciate your comment.

Dr. **Drew**. Well, Mr. Walker, I agree with—with your observation. The—in making that commitment, or at least in recommending that we make a commitment to the shuttle, I think what we saw there was we were transitioning to a—away from the single goal which, as you say, had no clear next step, except possibly a manned mission to Mars, say, to the planets.

We gave that some very serious consideration, as a matter of fact, and there are those who felt that the proper way to conduct the U.S. program, the U.S. Space Program, was indeed to proceed from these sort of major goals one on—after the other, with—with the consequences of that driving the kind of infrastructure development and so on. At—at that point, however, it appears that this question of a national consensus on the—not only that objective, but the pace at which you're going to proceed towards it, comes into play, and the number of alternative pressures and things that are pushing on Government and the people have to be weighed.

Frankly, when I said in my remarks that I believe that we will go to the planets with men, I think that's sort of implicit; it's buried in that commitment to take the next step, which is to put man into a permanently manned habitat. I believe, as a matter of fact, that it's—the way we're treating it now will preclude having this become the sort of—the goal with no—no complete follow-on. I think, as a matter of fact, we're seeing this as a stepping stone which puts us into space and allows us to do many other things.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Smith.

Mr. SMITH. I have no questions.

Mr. NELSON. Did any of the other three of you, in addition to Dr. Wilson that commented on the shuttle pricing policy, have any comment on shuttle pricing?

Mr. ROBINSON. Yes, we did.

Mr. NELSON. Go ahead.

Mr. ROBINSON. Basically——

Mr. NELSON. Turn on your mike.

Mr. ROBINSON. Am I turned on?

We also felt that—basically, that the pricing arrangement that exists right now is not competitive for the orbiter and there is a section in our written testimony that addresses that.

Mr. NELSON. In other words, you're saying that it is not too high, and therefore, would not be competitive, as you——

Mr. ROBINSON. That's——

Mr. NELSON [continuing]. Apply that on out to the 1989——

Mr. ROBINSON. That's correct, and I——

Mr. NELSON [continuing]. 1990 and 1991.

Mr. ROBINSON [continuing]. Think that that whole issue, we felt, needs more investigation.

One thing, if you bring more shuttle orbiters in the fleet, all the base costs are paid for your communications and the cost per flight should go down considerably if you can maintain the carrier as being the prime carrier for payloads into orbit.

Mr. NELSON. OK.

Gentlemen, we—yes, Mr. McLucas.

Dr. MCLUCAS. I would like to say a word on that. I think that we make a mistake when we judge the shuttle on the basis of how competitively it can launch communication satellites. Although NASA fell into that trap in the early days and said we're going to build a shuttle that will be great for that type of work, I don't think that's the kind of work that it's ideally suited for. And if it turns out that, for example, we could make major improvements in what we claim we're going to do, namely, commercialize space by allowing expendable launch vehicles to find a place in a commercial world—in other words, I think we can get better competition between expandable launch vehicles competing with Ariane than we can taking this huge shuttle and using it as a communications satellite launcher. That's not its major function.

Mr. **Nelson**. Do you have a dollar figure you want to suggest to us?

Dr. **McLucas**. No, but I think that the numbers that—well, here I think the OTA report—I'm sorry, Congressional Budget Office report gives some numbers in the 75, 85 range which seem to me—75, 85 million—seem to me to be not unrealistic because there is this tendency, no matter what price we put on it, the Ariane price will be one dollar less.

Mr. **Nelson**. Or maybe 10 percent less.

Dr. **McLucas**. But it would certainly be based on it.

Mr. **Nelson**. Anybody else?

Gentlemen, we thank you very much. We appreciate your participation.

I'd like to call up Congressman Ed Zschau from California who is going to address us.

I would recommend to my colleague that, due to the lateness of the hour and your patience, we appreciate very much, if you would just like to summarize with us, we will enter into the record your formal statement and if you would just like to share with us in summary in conversational manner, we'd be delighted to hear from you.

STATEMENT OF HON. ED ZSCHAU, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. **Zschau**. Thank you very much, Mr. Chairman. That's fine with me. I appreciate your including in the record my written statement. It deals with two aspects, both of which affect my congressional district, which, as you may know, is the area in northern California referred to as Silicon Valley. It includes Stanford University. It includes a variety of electronic firms and at least one company that has aspirations to be in the expendable launch vehicle business.

One issue that I wanted to bring to your attention is an experiment that's taking place at Stanford University which some scientists have described as the "experiment of the century." It's an experiment that involves putting very precise gyroscopes into Earth orbit to measure the effects on the warpage of space-time by a gravitational field that would be predicted by Einstein's general theory of relativity.

Although we've had many tests of the special theory of relativity, we've never really had a complete test of the general theory of relativity. The implications of measuring this and determining whether it's accurate could detemine to a significant extent our theories about cosmology and the way the universe was created. It may not affect what we're doing here in Congress, but for the scientists, it certainly is important.

The subcommittee last week put into the authorization bill a $10 million amount for fiscal year 1986 for this project, I would urge the full committee to adopt the recommendation of the subcommittee. This will keep this program on schedule. It's slated to put these very precise gyros into orbit about 1989, and it will take a couple of years to get the data. But if it is successful—and based on my assessment it will be successful—it is a Nobel prize class experiment which will have taken from conception to completion 30 years to do. I would hate at this point, when we're so close to getting the conclusive data, to have the funding that's so necessary right now curtailed.

So that is my first request, for the committee to retain for what's called the Gravity Probe-B experiment a funding level recommended by the subcommittee of $10 million.

The second item that I wanted to discuss, you've been discussing with prior witnesses. That has to do with the shuttle pricing. I have my own thoughts about that. My feeling is that we should be going to a full-cost basis for shuttle pricing in the 1989-91 time period, rather than subsidizing commercial users. And by "commercial users," I'm talking about people who are doing routine launches of satellites rather than basic research into space—the sort of work that the expendable launch vehicle business can do very well.

As was pointed out by Mr. McLucas, there are certain tasks of the shuttle for which only the shuttle can do the job, and there are other tasks for which really the shuttle is overkill. It would seem to me that what we should be doing is using a full-cost pricing scheme for those routine commercial launches. Why? Because if we continue to subsidize, not only do we lose revenues, but we make it very difficult for these fledgling new businesses in the expendable launch field to get started. They're competing, essentially, with big subsidized government competitor, namely NASA, where if we use the full-cost approach, it gives them an opportunity to compete.

The argument is made: Well, what about Ariane? Won't they have a lower price? The answer is "yes," as the prior witnesses indicated. They'll always have a lower price, whether NASA prices high or low, they'll always be below.

So I think that we should be going to a full-cost system for that reason.

What is the specific number? I've made a proposal in my prepared statement, but it's really not based on my own work; it's based on the CBO estimate using full cost minus the design development testing and evaluation cost, which comes up to $106 million in 1982 dollars per launch. I go through some analysis to indicate that if we use that as the price for launches, that rather than the prices that have been proposed by the subcommittee, NASA would get additional revenue of between three-quarters of a billion dollars and a billion dollars over that 3-year time period.

In conclusion, I just point out that I think we should make sure that NASA's mission is focused on basic research. There have been some indications in NASA publications that they want to capture a certain share of the commercial launch market and they're going to try to act in a competitive way vis-a-vis private competitors, both foreign and domestic. I think that NASA has no business being in business. It should be in basic research and providing the foundation that then allows the private sector to exploit the developments that they have made.

I appreciate, Mr. Chairman, the chance to summarize these points, which are more fully described in my written statement. Thank you for your attention.

[The prepared statement of Mr. Zschau follows:]

A STATEMENT BY

ED ZSCHAU

MEMBER OF CONGRESS

COMMITTEE ON SCIENCE AND TECHNOLOGY

MARCH 26, 1985

on the

NASA Authorization for Fiscal Year 1986

SUMMARY

1. The Gravity Probe-B (GP-B) experiment should be funded in FY1986 at a level of $10 million.

- The GP-B, which would be the first comprehensive test of Einstein's General Theory of Relativity, is in the eyes of many scientists "the most important scientific experiment this century."

- The GP-B experiment has spawned the development of important technologies in precision fabrication, magnetic field shielding, and gyroscope technology, and is providing a unique educational experience for graduate students in science and engineering.

- Funding the GP-B experiment at the level of $10 million in FY86 is needed to keep it on schedule for completion in 1989. Even so, if the experiment is successful, it would be a prime candidate for a Nobel prize and will have taken 28 years from conception to completion.

2. The pricing of space shuttle launch services should be based on "full cost" in the 1989-91 time period rather than subsidizing commerical users of the shuttle.

- Taxpayers should not be asked to subsidize the operations of private firms using shuttle launch services;

- If NASA offers subsidized launch services, it will be difficult for the private sector launch service firms to compete, thus hindering America's access to space;

- Arianne, the European launch firm will likely charge users at least 5 percent less than the shuttle price, no matter how low or high it is. Raising the shuttle price would probably result in a comparable increase in Arianne's price, thereby increasing incentives for private U.S. ELV firms to enter the market to compete for routine satellite launch service.

- The "full cost" on which the shuttle price should be based can be best determined by holding the shuttle to private sector standards. The CBO estimate of "full cost" minus design, development, test, and evaluation, which is $106 million (1982 dollars), seems appropriate assuming 24 launchers per year.

- A "full cost," inflation-adjusted price of $106 million would average about $82 million greater per launch in 1990 than the subcommittee's recommended pricing formula, resulting in a subsidy of at least $738 million during the 1989-1991 period.

3. NASA should use funds to continue its research activities rather than subsidize commerical businesses.

A STATEMENT BY
ED ZSCHAU
MEMBER OF CONGRESS
BEFORE THE
COMMITTEE ON SCIENCE AND TECHNOLOGY
MARCH 26, 1985
on the
NASA Authorization for Fiscal Year 1986

INTRODUCTION

Mr. Chairman, I'd like to thank you and your commitee for giving me the opportunity to testify today on some of the issues that are raised in the NASA Authorization for Fiscal Year 1986. The issues addressed in the bill relating to basic research and space commercialization are particularly important to my district which includes Stanford University, the Silicon Valley electronics industry, and at least one company that is designing a rocket for the purpose of launching commerical payloads.

I am here today to urge the committee to fund the Gravity Probe-B experiment at a level of $10 million in FY86 and to adopt a full cost pricing formula for shuttle services. I'd like to explain why.

The Gravity Probe-B (GP-B) Experiment Should Be Funded in FY1986 at a Level of $10 Million.

Mr. Chairman, last Thursday the Subcommittee on Space Science and Applications adopted an amendment to H.R. 1412 that would authorize $10 million for the Gravity Probe-B (GP-B) experiment in Fiscal Year 1986. I hope the full committee will accept the subcommittee's recommendation.

The Gravity Probe-B experiment will be an important test of Einstein's General Theory of Relativity. This theory is the basis of our current understanding of the universe. It states that gravitation is actually a "warping" of space-time caused by objects in the universe. The theory has given rise to such concepts as the "expanding universe" and "black holes" -- objects in distant space that are so dense and have such a strong gravitational force that even light rays are captured by them.

GP-B has been identified by the National Academy of Space Science Board as the one free flying relativity mission it recommends for the 1980's. Furthermore, GP-B is widely acclaimed as "the most important scientific experiment this century."

GP-B experiment is based on observations of extremely precise gyroscopes (1,000,000 times more precise than our best gyroscopes today) in Earth-orbit. If Einstein's theory is correct, the gyroscope should precess (change its axis of spin) because of the "warping" of space by the earth's gravitational field and the "dragging" of space and time due to the earth's rotation. The amounts of such precessing are incredibly small, thus requiring precision gyros, an isolated environment, and extremely sensitive measurement systems.

Besides the breakthrough in gyroscope technology, GP-B has led to the invention of a method for obtaining ultra-low magnetic fields, a new kind of precision telescope, a "drag free" satellite and a "porous plug" for controlling the flow of liquid helium in zero gravity.

In addition to GP-B's results, which will broaden our understanding of the universe, and its spin-off technologies, the experiment has strengthened our nation's educational capability in science and engineering. At Stanford University, students have played an active role on the GP-B. In fact, various aspects of the GP-B experiment have been the subject of 23 doctoral dissertations at Stanford.

The subcommittee's recommended authorization will allow the GP-B program to continue on-cost and on schedule, which will culminate with the actual test of Einstein's Theory when the gryoscope satellite is released on a shuttle mission in 1989. At that time, the experiment will be 28 years old and if successful, will be a prime candidate for a Nobel prize.

The Pricing of Space Shuttle Launch Services Should be Based on "Full Cost" in the 1989-91 Time Period Rather Than Subsidizing Commerical Users of the Shuttle.

The pricing of space shuttle launch services affects the incentives for taking risk on new technologies and products that might be manufactured in space, as well as incentives for those companies who may offer transportation to space. It also affects the market opportunities for firms that successfully develop new technologies in space, those who offer "upper stages" for the shuttle, and those who may offer launch services.

I agree with President Reagan's order that shuttle users pay the full cost of shuttle launch services in the 1989-91 time period. Anything less than "full cost recovery" would mean that our commercial space program would cause federal spending and deficits to increase in the "out years." It would mean that taxpayers would subsidize the commercial operations of private firms, which is inconsistent with our free market system.

I fear that charging shuttle users less than the full cost would make the space shuttle into the Amtrak of the 1990's. Amtrak was originally chartered as a for-profit entity in 1971. In 1984, passenger ticket prices only covered 58% of costs to operate the trains, excluding depreciation, taxes, and labor protection. Since its inception, Amtrak has cost the American taxpayer nearly $9 billion. Extending shuttle subsidies past 1988 could cost taxpayers nearly $1 billion dollars by my estimate over the three year period of 1989-91.

Of course, if NASA charged users the full costs it may lose customers to private ELV firms, particularly Arianne. This should not give rise for concern in formulating U.S. space policy. If for instance, the highly subsidized Arianne would take some of the shuttle's business, I see no problem in allowing U.S. businesses to take advantage of subsidies offered by European taxpayers. But it certainly doesn't justify penalizing American taxpayers in an attempt to offer the biggest subsidy to commercial busineses. I believe that whatever we charge commercial users of the shuttle, Arianne will probably charge at least five percent less.

If we are to require that commercial users of the shuttle pay for the full cost of services, we are still left with the question: "What is the full cost?" This question has set off a bookkeeping debate among interested parties that will only be settled in hindsight. Just like Congress really didn't know whether Amtrak would make money back in 1971, we really won't know how much taxpayers subsidize or profit from shuttle launches until after a series of missions are completed.

In making our best guess of future shuttle costs, I would urge that we should hold the shuttle to the standard that private firms use in accounting costs. A recent publication by the Congressional Budget Office (CBO) entitled "Policy Options for the Space Shuttle" provides the kind of analysis that we in Congress and the Administration should consider. The study suggests various pricing options based on various methods of accounting.

The only option that CBO presents that I feel realistically holds the shuttle to private sector standards is CBO's "full cost" estimate minus costs for shuttle development, design test and evaluation (DDTE) which were paid from 1972 to 1982. With no commercial markets, these DDTE costs would have been incurred to develop the shuttle so that NASA could meet its basic research mission. It is not proper, then that commercial users pay for these costs. However it is proper that commercial users pay for all operational costs plus depreciation and shuttle replacement costs.

According to CBO, accounting for these costs would require a shuttle launch price of $106 million (1982 dollars) assuming 24 flights per year. With only 12 flights per year, the price would need to be $170 million per launch to recover costs. Because of the unpredictable nature of shuttle scheduling, it would seem appropriate that a floor price be set that would recover full costs of shuttle services under ideal conditions, but would allow the price to increase if conditions warranted. Unless there are better estimates of full cost minus DDTE, I would urge that NASA adopt the CBO figure of $106 million (1982 dollars) for commercial launch service in 1989-91.

During the markup on H.R. 1412, the subcommittee adopted a provision that would require NASA to charge $45 to $71 million for commercial launch services in 1989-91. It may be illuminating to perform some computations to determine the impact of this proposal on federal spending and the deficit. If the CBO estimate is taken as the proper full cost for shuttle users, the CBO figure in 1990 dollars is about $140 million. If we assume a 1990 average price under the subcommittee recommendation of $ 77 million, the American taxpayers would provide an average subsidy to private sector users of $63 million dollars per launch -- even higher if there are less than 24 launched per year. At a rate of 3 commercial launches per year, the total subsidy for the 1989-91 time period would be at least $567 million. With less than 24 launches per year, the figure could easily approach $1 billion. I respectfully submit that such a policy is not consistent with efforts to reduce the massive federal budget deficits that inhibit U.S. industrial competitiveness.

NASA Should Use Funds to Continue Its Research Activities Rather Than Subsidize Private Businesses.

The price that our government charges commercial users of the shuttle for launch services will have a major impact on those who might compete with the shuttle for launch services. These companies include firms who have long been NASA contractors and developed rockets such as the Titan, the Delta, and the Atlas-Centaur. Other start-up firms are also interested in developing the capability to launch commercial payloads, while still other provide an "upper stage" for the shuttle that can be used to boost satellites into geosynchronous orbits.

Unfortunately, it appears that NASA may view ELV's as a threat to the shuttle rather than a complement to their operations, even though present plans call for only 2 to 4 commercial launches per year. In a shuttle marketing proposal issued in May, 1984, NASA expressed the intent to capture 70% of the commercial launch market. In a printed presentation, NASA indicated that it would "evaluate (the) competition's marketing approach" and "recommend a general approach to counter competition" and "specify individual customer strategies to increase STS competitive advantages." I feel that such a marketing strategy is inconsistent with the spirit of the Administration's economic policy and OMB Circular A-76, which states that "in the process of governing, the Government should not compete with the private sector."

Starting and operating a business is tough enough without competition from the government. NASA should direct its resources towards basic research, which has proven many times to be the agency's forte, rather than compete with businesses in the private sector.

CONCLUSION

Mr. Chairman, the committee has the opportunity to continue

to spur innovation and entrepreneurship in the United States by encouraging NASA to focus it efforts on basic research programs such as GP-B that will not be done by the private sector. Such research also increases our nation's educational capability in the sciences and engineering.

Basic research and university education are appropriate areas for government support. In my view, subsidizing commercial launch services makes NASA an unfair competitor with the private sector, which will discourage competition and limit America's access to space. I hope the committee will act to insure that our nation's scientists and engineers are given the greatest freedom possible to explore new ideas by adequately funding basic research programs such as GP-B. I also hope that the committee will insure that the innovators and space entrepreneurs in the private sector who might offer launch services have the greatest freedom to commercialize their ideas without subsidized competition from an agency of the federal government.

Mr. **Nelson**. I appreciate you taking the time to come and share with us. I thank you for your compliments about us upping the administration's recommendation with regard to Gravity Probe-B, which we've done, and a member of our committee worked directly on that, Norman Mineta, who—whose district borders yours, as I understand, there in the upper portion of California. So it's our pleasure.

Let me tell you, I'm beginning to feel like that I know a lot more about shuttle pricing than I ever wanted to know in my life. We've spent considerable time in this committee, both publicly and privately, discussing this issue, and I wish that you could say that that was one of the issues in public life that was clearcut as to what it should be. There are a number of variables that are working.

Certainly, you have pointed out one: the French and the commercial satellite market through Ariane and their subsidy of their particular pricing policy, but beyond that, you have basic questions of the viability of any existing U.S. ELV launcher being able to be competitive with Ariane, completely excluding the shuttle as a launch vehicle under that analysis.

In addition to that, you have the question of utilization of a vehicle, getting maximum utilization, driving down your per-flight cost because of being able to utilize the standing army that's in place for the DOD missions and the NASA scientific missions and being able to get the most out of that vehicle. You have to factor in that equation.

Then you have to factor in the—into the equation also the fact that the French have built a new rocket with up-to-date technology and up-to-date assembly lines, as compared to older rockets that have been very successful, U.S. rockets, that have been proposed by two specific enterprises. And at this point, we're talking about basically two that have come and testified as ELV commercial launchers.

That, and a lot more that I won't go into, has led to extensive deliberation and consideration and building of consensus and differing of opinion as we have sought our way through this.

Now, let me just tell you that we started out in a position on pricing when we marked up last week and we will always keep our eyes and ears and minds open as we proceed. In about a week—a month or two, the Senior Interagency Group, of which NASA is a member, will be deliberating on this issue, so over the time, as we move through the legislative process, there's going to be additional time for further information to be received and that's the way that I intend to conduct it as we go all the way through into the conference committee with the Senate.

Mr. Walker.

Mr. **Walker**. Thank you, Mr. Chairman. Just a couple of points.

As the chairman well knows, Mr. Lujan also worked hard on the Gravity Probe-B problem here in the subcommittee and helped push for that and, as the chairman has indicated, there is a difference on this committee with regard to pricing policy. I happen to favor a flexible approach that goes all the way from about $45 million, which in the CBO study to which you referred was the marginal cost at the low end, but then goes all the way up to the $106 million primarily designed to utilize the $106 million price for those loads that are not shuttle-specific, that do not meet the—the developmental kinds of criteria that you're talking about and also would not take us to a point where we're losing market share. My amendment—my approach also included NASA keeping a market share for the United States so that Ariane did not get it.

We—we have a difference of opinion here attempting to come up with a—with a pricing policy, but I do think that some flexibility in the pricing policy would serve our best ends right now, at least until we see what the impact of the 1990's is going to be.

I think to—to lock in pricing policies that drive us into the 1990's may not be the best decision for us at the present time.

Mr. NELSON. All right. We appreciate our colleague coming and sharing his thoughts with us and you have a good day.

Mr. ZSCHAU. I want to thank you, Mr. Chairman, and I fully appreciate the complexity of the pricing issue, but I have a great deal of confidence that you and this committee will resolve it in an appropriate fashion.

Thank you.

Mr. NELSON. Well, we thank you and I want to announce that tomorrow the markup in the full Science and Technology Committee will commence at 11, instead of 9:30, as originally announced, and that will be right here in this room, 2318.

Thank you all and have a good day. The meeting is adjourned.

[Whereupon, at 3:15 p.m., the subcommittee was adjourned, to reconvene at 11 a.m., Wednesday, March 27, 1985.]

APPENDIX 1

RESPONSES TO QUESTIONS FROM CHAIRMAN GLICKMAN ON THE FY 1986 CONGRESSIONAL BUDGET

QUESTION 1:

Please provide historical trend data (FY 1982 through FY 1986) showing the number of trips taken and planned in three travel categories. Data should be normalized to end-of-year FY 1985 professional personnel ceiling.

ANSWER 1:

The historical trend normalized to end-of-year FY 1984 professional personnel ceiling is provided below:

	FY 82	FY 83	FY 84	FY 85	FY 86
Normalized Trips:					
Program Travel	33,180	34,642	36,684	38,300	38,900
Management & Operations Travel	6,872	9,690	9,059	8,600	8,100
Scientific & Technical Development Travel	3,721	4,118	4,032	6,100	6,200
Normalized Total	43,773	48,451	49,775	53,000	53,200
Total Actual Trips	43,037	48,796	49,162	53,000	53,200

QUESTION 2:

What is the amount, by agency, expected in FY 1985 and FY 1986 from other agencies and commercial customers to reimburse NASA for the salaries and benefits of civil service employees? How many employees do these funds cover? What other funds are provided, by agency, to cover other R&PM costs?

ANSWER 2:

Listed below are the dollars expected in FY 1985 and FY 1986 from other agencies and commercial customers to reimburse NASA for the salaries and benefits of civil service employees and the number of workyears covered.

	FY 1985		FY 1986	
Agency	Amount	Workyears	Amount	Workyears
	($ in thousands)			
Department of Commerce	4,878	86	3,461	62
Department of Defense	4,865	83	5,981	105
Non-Federal	2,295	69	220	5
Total	12,038	238	9,662	172

Listed below are other funds provided, by agency, to cover other R&PM costs.

Agency	FY 1985 Amount	FY 1986 Amount
	($ in thousands)	
Department of Commerce	1,444	1,182
Department of Defense	6,889	6,316
Other Government agencies	3,924	3,050
Non-Federal Sources	15,705	15,790
Total	27,962	26,338

QUESTION 3:

Please provide trend data (FY 1982 through FY 1986) showing utility usage (BTU's) and total costs.

ANSWER 3:

The R&PM utility energy usage (source BTU's) and the R&PM total utility function costs are as follows:

	FY 82	FY 83	FY 84	FY 85	FY 86
Billion BTU	14.7	15.3	16.1	16.5	16.9
Cost in Millions	67.5	77.4	83.3	96.2	108.8

QUESTION 4:

What is the number and cost, by Center, of reimbursable detailees and R&D funded post-graduate fellows for FY 1985 and FY 1986.

ANSWER 4:

	Reimbursable Detailees				Post-Graduate Fellows			
	1985		1986		1985		1986	
Installation	Wkyr	$	Wkyr	$	Wkyr	$	Wkyr	$
ARC	9	367	9	378	55	2,405	55	2,420
GSFC	—	—	—	—	44	1,855	44	1,936
HQ	11	474	11	461	—	—	1	44
JSC	73	3,938	73	3,853	20	798	20	822
KSC	1	46	1	48	—	—	1	44
LaRC	—	—	—	—	17	750	17	748
LeRC	—	—	—	—	15	664	17	748
MSFC	—	—	—	—	11	475	11	484
NSTL	—	—	—	—	1	43	2	88
NASA TOTAL	94	4,825	94	4,740	163	6,990	168	7,334
				JPL	34	1,453	32	1,408
				TOTAL	197	8,443	200	8,742

QUESTION 5:

What is the baseline number, by center, of R&PM support contractors in FY 1985 and FY 1986? What are the costs associated with the total number of SSC in FY 1985 and FY 1986?

ANSWER 5:

The baseline values for R&PM support contractors for FY 1985 and FY 1986 are shown by Center in the table below:

CENTER	FY 85 Est	FY 86 Est
ARC	280	286
GSFC	480	466
HQ	163	160
JSC	841	796
KSC	1,428	1,391
LaRC	289	281
LeRC	302	304
MSFC	540	528
NSTL	27	38
NASA TOTAL	4,350	4,250
Costs (In Millions)	$169.5	$176.3

QUESTION 6:

How much is included in FY 1985 and FY 1986 for lease, purchase, maintenance and operations of ADP equipment?

ANSWER 6:

The FY 1986 R&PM budget estimate provides for the following:

	FY 1985	FY 1986
	(Dollars in Thousands)	
ADP Equipment	7,539	9,162
ADP Operations	32,189	38,886
TOTAL	39,728	48,048

QUESTION 7:

For FY 1985 and FY 1986, what is the cost of rental of land and property? How much space is leased?

ANSWER 7:

The R&PM FY 1986 budget estimate provides for the following:

	FY 1985	FY 1986
Total Costs ($ in thousands)	8,920	8,853
(Rental from GSA)*	(8,521)	(8,487)
Total Space Leased (sq. ft.)	576,315	570,420
(Rental from GSA)*	(565,451)	(560,900)

*Includes Standard Level User Changes (SLUC) paid to GSA mainly for NASA Headquarters use of Federal office buildings in the District of Columbia.

QUESTION 8:

How much is included in FY 1985 and FY 1986 for rental of passenger vehicles (except GSA), GSA passenger vehicles, movement of goods and administrative aircraft operations. How many vehicles are covered by these funds? Also, show dollar amounts for and number of vehicles provided to contractors.

ANSWER 8:

	Total	
	1985	1986
Rental of Passenger Vehicles (Except GSA)	$68	$68
Rental of GSA Passenger Vehicles	$1,500	$1,890
(Contractor)	(60)	(65)
Movement of Goods	$3,053	$2,897
Administrative Aircraft Operations	$6,618	$6,189
Number of Vehicles Covered	310	310
(Contractor)	(20)	(20)

QUESTION 9:

Summarize the results of the NASA EEO recruitment program over the past year..

ANSWER 9:

NASA continues to make progress in the area of equal opportunity. The Agency is dedicated to achieving its technical missions and goals with a fully integrated workforce. FY 1984 marked another historic milestone with two additional American female astronauts and an additional Black astronaut traveling in space on NASA Space Shuttle Flights 41-B, 41-D and 41-G, respectively. NASA's demonstrated commitment to affirmative action for women and minorities who are underrepresented is reflected in the FY 1984 Affirmative Action Program results.

In addition, 37 handicapped persons with targeted disabilities were hired including a disabled veteran with a 30% or more disability. This included 20 in permanent or positions leading to permanent assignments, and 25 summer hires utilizing a variety of summer employment programs. Thirty-one (31) severely handicapped individuals were promoted.

Hires

- o 328 scientists and engineers; 132 (40.2%) minorities and non-minority women.
- o 135 professional administrative; 62 (45.9%) minorities and non-minority women
- o 378 technicians, wage grade, and Cooperative Education Program employees; 161 (42.6%) minorities and non-minority women
- o 469 clerical support employees; 128 (27.3%) minorities.

Promotions

- o 1,859 scientists and engineers; 531 (28.6%) minorities and non-minority women
- o 709 professional administrative; 464 (65.4%) minorities and non-minority women
- o 1,324 technicians, wage grade and Cooperative Education Program employees; 405 (30.6%) minorities and non-minority women
- o 823 clerical support; 240 (29.2%) minorities.

QUESTION 10:

What are the costs, by Center, of both ETB and IMS for FY 1985 and FY 1986.

ANSWER 10:

	ETB		IMS	
Installation	1985	1986	1985	1986
	(Dollars in Millions)			
ARC*	—	—	13.5	14.0
GSFC	—	—	31.9	33.1
HQ	1.2	.6	—	—
JSC	70.7	72.8	37.8	41.3
KSC	3.0	3.1	—	—
LaRC*	—	—	29.0	30.0
LeRC*	—	—	23.0	24.0
MSFC	22.6	26.1	—	—
NSTL	8.2	7.1	—	—
TOTAL	105.7	109.7	135.2	142.4

*Represents Multi-Program Support (MPS) charges.

QUESTION 11:

Please provide data showing escalation rates for support contractors services.

ANSWER 11:

The escalation rates projected for support contractor services are shown in the table below:

Center	FY 1984 to FY 1985 % Change	FY 1985 to FY 1986 % Change
ARC	+6.8	+6.5
GSFC	+5.8	+5.6
HQ	+6.7	+4.1
JSC	+6.9	+6.6
KSC	+6.8	+6.6
LaRC	+6.3	+6.3
LeRC	+6.7	+6.4
MSFC	+7.4	+6.9
TOTAL NASA	+6.4	+6.4

QUESTION 12:

Summarize the results of the latest round of SES bonuses.

ANSWER 12:

In 1984, NASA, in accordance with the Office of Personnel Management's guidance, awarded bonuses to 35% of its SES career employees. A breakdown of the bonuses are as follows:

Number of Awardees	Percent of Salary	Amount of Bonuses
10	19%	$129,785
15	14%	143,850
20	11%	150,512
46	8%	246,794
65	5%	216,091
156		$887,032

In addition, seven NASA employees received Presidential Ranks, two distinguished and five meritorius. These employees received $81,600 as a result.

QUESTION 13:

Summarize the results of the most recent year under "merit pay".

ANSWER 13:

Merit increases in October 1984, were significantly affected by legislation which passed on October 10, 1984, with an effective date of October 1, 1984. Several hundred merit pay employees received smaller merit increases under the new law than they would have in NASA's original Merit Pay System. These employees, who fully satisfied the performance requirements of their jobs, are falling behind their peers who are paid from the General Schedule and received the same performance rating. This inequity is built into the statutory pay scheme and cannot be corrected by the Agency.

The new law provides for mandatory funding levels for cash awards for the covered employees. Because of the delay in publishing implementing instructions by the Office of Personnel Management, NASA has not paid its cash awards for the FY 1984 performance ratings yet. This is expected to be completed by mid-April 1985. The cash awards may mitigate, to some extent, the shortfall in increases to basic pay. NASA expects to pay out in FY 1985 about $2.7 million.

QUESTION 14:

Please provide a current listing of re-hired annuitants.

ANSWER 14:

The following is a list of former NASA employees currently employed as re-employed annuitants through September 30, 1984.

Re-employed Annuitants as of September 30, 1984

	Perm.	Temp.	Total
ARC	--	1	1
GSFC	--	--	--
HQ	3	26	29
JSC	--	5	5
KSC	--	10	10
LaRC	--	--	--
LeRC	--	--	--
MSFC	--	--	--
TOTAL	3	42	45

PERMANENT

HQ	Coy, Edward F. Jefferson, Dorothy M. Williams, Walter C.

TEMPORARY

ARC	Markey, Stanley
HQ	Rees, Eberhard Kilgore, Edwin C, Roman, Nancy G. Hoff, Harold L. Philarinos, George Fletcher, James C. Lawson, James R. Lovelace, Alan M. Shapley, Willis H.

	Elms, James C.
	Naugle, John E.
	Johnson, Vincent L.
	Lilly, William E.
	Himmel, Seymour C.
	Cortright, Edgar M.
	Donlan, Charles J.
	Lazar, James
	Olstad, Walter B.
	Karegeannes, Carrie E.
	Carter, Charles H.
	Rabin, Herbert
	Mathews, Charles W.
	Ludwig, George H.
	Myers, Dale D.
	Voris, Roy M.
	Vincenti, Walter G.
JSC	Parker, Frank P.
	Chaney, Baily R.
	Piland, Robert O.
	Norfolk, Robert A.
KSC	O'Connor, Jerry J
	Mizell, James F.
	Gauger, Paul C.
	Nick, D. Faye
	Yost, Ray E. Jr.
	Senstad, Kenneth P.
	Tatiani, Angelo J.
	Davenport, Jansen R.
	McRoberts, Joseph J.
	Whitaker, Philip F.

APPENDIX 2

NASA
National Aeronautics and
Space Administration

AEROSPACE SAFETY ADVISORY PANEL

ANNUAL REPORT

COVERING CALENDAR YEAR 1984

JANUARY 1985

AEROSPACE SAFETY ADVISORY PANEL

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ANNUAL REPORT

COVERING CALENDAR YEAR 1984

JANUARY 1985

I. EXECUTIVE SUMMARY

Focus of the Aerospace Safety Advisory Panel's activities during 1984 was directed to three broad areas of NASA's responsibilities:

1. The Space Transportation System (STS) operations and evolving program elements,

2. Establishment of the Space Station program organization and issuance of Requests for Proposals to the Aerospace Industry, and

3. NASA's aircraft operations, including research and development flight programs for two advanced "X-type" aircraft.

The majority of the Panel's activities were dominated by the STS.

This report summarizes the Panel's 1984 review activities and resulting observations, and enumerates the Findings and Recommendations which the Panel deem to be appropriate to highlight for NASA management attention. NASA's response to the Panel's 1983 annual report is appended hereto; any matters remaining "open" are noted in this Executive Summary.

Government and industry support of the Aerospace Safety Advisory Panel and its work continues to be excellent, thus enabling the Panel to fulfill its statutory responsibilities.

Panel Meetings

The full Panel, or individuals and smaller groups of Panel members, conducted 36 fact-finding sessions during calendar 1984. These included meetings at six NASA centers and seven contractor sites, and Vandenberg Air Force Base. In addition, the Panel presented testimony before the cognizant committees of the U.S. House of Representatives and U.S. Senate and held other discussions with congressional staff.

Space Transportation System Program

The STS increasing mission frequency places new demands upon both management and the "hands-on" personnel, which will remain at a high level. The standards set during the first 15 safe and successful missions are admirable and commendable. To maintain or even improve upon those standards will require exceptionally perceptive management and disciplined execution of the program. Among the more crucial program precepts, as viewed by the Panel, are: recognition that the STS is a program still in transition from "single event demonstration" stage to "operational" stage, and will remain such until the full operational capabilities (and limitations) are known in quantitative terms based on scientific/engineering proofs; recognition that complacency bred of repetition is an inborn human hazard and conscious steps to avoid same are essential; changes to hardware and software must be controlled to the degree necessary to avoid overloading the processing team's ability to safely implement them; changing contractual and personnel arrangements must be carefully planned in advance; recognition that quality requires strict discipline and is everybody's business everyday; and the logistics system, at a minimum, must be supported by its current level of attention and funding.

The successful Orbital Refueling Demonstration Test conducted during the STS-41G mission, the successful repair and retrieval missions with previously launched satellites, and the successful static firing of the first Filament Wound Case solid rocket development motor (DM-6) are good examples of well constructed and executed adjuncts that support mainline program activities.

Basically the numerous elements comprising the STS ground and flight subsystems have shown good performance and dependability. There are, not unanticipated, some individual components and subsystems which have yet to meet design expectations and are cause for concern as flight rate increases. These include actuators and valves, fluid leaks, instruments, Orbiter brakes, Orbiter external thermal protection tile subsystem and its waterproofing, and Orbiter structural restrictions. Shortages of flight-critical spares continue to require extraordinary measures for each launch preparation.

Taking all of this into account, NASA's planning for the near term use of STS resources and for procedural adaptiveness continues to be thoughtful, thorough, and meets current mission needs during this STS transition period, albeit all the while drawing upon a slim logistics support base.

The Panel has recommended the use of Orbiter-102 as a combined payload carrier and a development vehicle. With its large array of instrumentation and recorders, OV-102 is an ideal vehicle to acquire the quantitative data necessary to fully define the Orbiter's performance capabilities and enhance the data base for future vehicle design. The STS program office concurs and a detailed plan dovetailing mission requirements and R&D needs is being constructed.

Specific Findings and Recommendations relating to the STS program are summarized in Section II of this report and are discussed in greater detail in Appendix D. Topically they concern:

1. STS Launch Processing and Logistics
2. Space Shuttle Main Engines
3. Space Shuttle Solid Rocket Boosters
4. STS Orbiter Structural Life Certification and Adequacy
5. Extra Vehicular Activities (EVA) and Life Sciences
6. Using Orbiter OV-102 in an R&D Role
7. KSC and VAFB Common STS Operations
8. Shuttle/Centaur
9. Radioisotope Thermoelectric Generator (RTG) as a Spacecraft Power Source

Space Station

The Panel was briefed by the program management principals at both JSC and NASA Headquarters on the Space Station concept and plans that are currently being implemented. Early exposure to the program was sought by the Panel to enable it to follow safety-related matters from the conceptual decisions onward through the design, development, and operational stages. The Panel's areas of interest in Space Station will include manned transportation, construction, residency, operations, maintenance, EVA, hazard exposure, escape and rescue, and the safety organization and safety requirements associated with foreign participation. The Panel believes Life Sciences and Space Medicine considerations must be among primary design criteria. It is similarly essential that the Space Station be designed for on-orbit maintenance, as basic design criteria.

NASA Aircraft Operations

The NASA Administrator has provided specific guidance regarding aircraft flight operations policies and procedures to achieve safe, efficient, and productive flight programs. The NASA Headquarters Aircraft Management Office has taken a number of steps to implement the Administrator's directions, including management instructions, revisions to the basic Safety Manual, and assurance of periodic review of each center's flight operations and safety programs.

For the first time in a number of years NASA is directly involved in flight testing "X-type" aircraft, the X-29 and the X-Wing aircraft. Both involve state-of-the-art-and-beyond technical status with attendant experimental flying risks. The Panel has initiated steps to stay abreast of the conduct of these flight testing programs.

NASA Response to ASAP 1983 Annual Report

The Panel's 1983 Annual Report was responded to by NASA with in-depth briefings at JSC and in writing by the Administrator (see Appendix E.). Most of the items are now considered "closed", based on either adequate explanation or implementation or plans to accomplish the activity. There are, however, some items regarding the STS that will continue to be of interest to the Panel.

The Panel continues to believe strongly that there are many benefits to be gained from reducing landing speed of the Orbiter (ref. 1983 Annual Report Conclusion and Recommendation No. 6). While the Panel accepts NASA's response regarding the impracticability of installing a specific solution such as canard control surfaces on the present Orbiter vehicles, the Panel urges NASA to continue to seek other, more readily adaptable solutions.

Other major areas of the STS such as Product Quality, the Orbiter External Thermal Protection System, Orbiter Structural Adequacy, Space Shuttle Main Engine improvement program, and maturing launch operations at Kennedy Space Center (KSC) and Vandenberg Air Force Base (VAFB) will continue to be followed during 1985. In addition, the Panel will "touch base" on specific hardware items such as Orbiter brakes, anti-skid system, nose-wheel steering, Auxiliary Power Unit, and General Purpose Computer improvement program.

NASA Aircraft Flight Operations are still undergoing change and will be further reviewed by the Panel.

II. Findings and Recommendations

1. Launch Processing and Logistics

FINDINGS

The transition to the Shuttle Processing Contractor (SPC) was achieved in early 1984. The SPC and NASA are both to be commended for commitment of effort and dedication to success of the concept.

Each subsequent launch processing sequence to date has generated an unexpected burden of modifications, change-outs, repairs, and maintenance tasks. Launch processing has thus been anything but routine and there is no reason to believe that "routine" operations are likely to be achieved in the near future. In effect, the STS is presently in a period of "developmental evolution" wherein a number of key systems will be changed and, one hopes, improved.

The Shuttle Processing Contractor (SPC) is struggling to handle the burden of work associated with each mission. The problems arise in part from difficult engineering tradeoffs and need for sufficient advance planning of modifications to the Orbiter; unexpected replacement of parts; some shortage of qualified spares at KSC; lack of necessary piece parts; some shortage of qualified technicians in certain disciplines, and heavy paperwork burden. The SPC must also assume launch processing responsibilities at Vandenberg Air Force Base using many of the same persons working at KSC.

Although serious, these transitional problems are neither unusual nor unexpected, given the complexity of the STS, its state of continuing development, and the large number of personnel and institutions that must collaborate in launching the Shuttle. The challenge to NASA is to move through this period of "developmental evolution" in a way that makes feasible a sustained period of "operations" into the next century. In other words, efforts and expenditures now to improve the reliability, maintainability, and safety of key STS systems should pay off handsomely in future years.

RECOMMENDATIONS

1. NASA management should continue to allocate the human and financial resources required to maintain acceptable levels of safety in what in many respects is still a developmental program from the point of view of the ultimate use of space as well as the maturity of the system.

2. Modifications to the Orbiter--such as the main engine, structure, avionics, and brakes--should be directed at improving reliability, maintainability, and safety as well as achieving additional increments in performance.

3. NASA management should make a concerted effort to identify and prepare for Orbiter modifications prior to commencement of the launch processing sequence. "Freeze point" discipline must be maintained. Unexpected changes and modifications must be held to a minimum if the Shuttle Processing Contractor (SPC) is to achieve the projected flight rate.

4. Vesting overall Shuttle management in an "operations entity" at NASA Headquarters would help achieve acceptable levels of efficiency, productivity, and schedule reliability during this period of "developmental evolution." The Panel has made this recommendation in past years and NASA management is presently examining this and related issues through the Shuttle Operations Strategic Planning Group, the Smylie Committee.

5. NASA management would be well advised to avoid advertising the Shuttle as being "operational" in the airline sense when it clearly isn't. More to the point, however, is the fact that Shuttle operations for the next 5 to 10 years are not likely to achieve the "routine" character associated with commercial airline operations. Given this reality, the continuing use of the term "operational" simply compounds the unique management challenge of guiding the STS through this period of "developmental evolution." NASA should continue to focus on making the STS as efficient, productive and reliable as possible while the research and development flights are defining the commercial use of space.

2. Space Shuttle Main Engines (SSME's)

FINDING

The three phase program to improve the SSME that was initiated last year has been restructured so as to provide a long term SSME technology program while staying within the FY 1985 congressional budget. The modified program will not achieve all of the original objectives. It will, however, result in a more reliable and durable engine for operation at 104% Rated Power Level (RPL) thrust with significant margin. Operation at 109% RPL thrust with improved but limited life, under hardware performance constraints will be possible. To achieve additional margin and/or additional life at 109% RPL thrust requires the incorporation of the large-throat main combustion chamber now relegated to the "Precursor" program, a technology-oriented program looking at long-range engineering advancements.

RECOMMENDATION

The modified improvement program should be pursued vigorously. All reasonable effort should be exerted to develop the new hot gas manifold and to incorporate it at the earliest date feasible. Activity to reduce start and shutdown temperature transients should be added to the "Phase 2+" program. Mission planning should continue to consider 104% RPL thrust as the normal operating level for the engines. 109% RPL thrust should be employed only for those missions dependent on the higher thrust and as an abort capability.

3. Space Shuttle Solid Rocket Boosters (SRM/SRB)

FINDING

The Solid Rocket Motor filament wound case may exceed flight to ground system clearance interface limits due to the filament wound case being more flexible than the steel case. Data indicate that the modal frequencies of the filament wound case are even lower than first estimated due to filament wound case joint free-play.

RECOMMENDATION

An analysis and tests be performed on the filament wound case with the total stack to establish lift-off loads and vehicle excursions considering the lower modal frequencies.

4. Orbiter Structural Life Certification and Structural Adequacy

(1) FINDINGS

The structural life certification program for the Orbiter is based on supplemental full-scale tests. However, two extremely important tests on the wing have not yet been conducted which leaves the certification plan incomplete. The full-scale test for these two articles are very expensive and show negligible fatigue damage based on a current simple analysis.

RECOMMENDATIONS

The Panel agrees with the decision to certify these two articles by analysis. A detailed analysis plan for the two test articles should be developed and implemented to fulfill the certification program for 100 missions.

(2) FINDINGS

The Space Shuttle has to fly in regimes requiring high performance missions with adequate launch probability. The new "ASKA 6.0" Loads/Thermal/Stress cycle program is an important part of certification because flight-measured data show that the wing normal forces were larger and more aft than the ASKA 5.1 and ASKA 5.4 design loads. The ASKA 6.0 Loads/Thermal/Stress cycle will not be completed until 1987. In the meantime, the Orbiter capability assessment (OCA) plan, employing current algorithms, derived from flight test, has been used to make launch decisions using a negative $q\alpha$ profile resulting in a loss of performance. Some wing/fuselage modifications have been made and others have to be completed in order to expand the Orbiter flight trajectory for future flight missions. The flight and wind tunnel aerodynamic data base used for the 6.0 Loads/Thermal Stress cycle (available in 1987) may not be verified by the data from OV-102 instrumented flights. The proposed structural modifications will probably not eliminate the restrictions now being required in flight.

RECOMMENDATIONS

Conduct a systematic review and document the structural differences, safety margins and major logistics impacts for each Orbiter vehicle. In recognition of these differences, baseline the performance envelope for each Orbiter and, as required, determine the trade-offs between any structural/aerodynamics modifications and performance.

5. Space Extra-Vehicular Activities (EVA's) and Life Sciences

FINDING

EVA will continue to be extensively used, both planned and impromptu. The Space Station will require considerable EVA initially for its construction and later for operational activity. While the current suit has performed well, within its limitations, there is need for a new EVA suit with improved flexibility and higher internal operating pressure. Such a concept is in the early development phase in NASA and needs to be funded for further development and possible production as a replacement for the current EVA suit.

RECOMMENDATION

NASA should encourage the development of an advanced higher pressure EVA suit to replace the existing unit.

6. Use of Orbiter-102 in R&D Role

FINDING

In responding to pressures for improved performance there will be a continuing need to expand the STS ascent and Orbiter descent flight envelopes (trajectories) creating the need to obtain flight data measurements relating to structural loads and aerodynamic behavior.

RECOMMENDATION

Orbiter OV-102 is the most suitably instrumented of the Shuttle fleet and should regularly be utilized as a research and development vehicle in addition to its normal mission activities.

7. Kennedy Space Center (KSC) and Vandenberg Air Force Base (VAFB) Common Operations

FINDING

In the near future, at least in part, common launch crews will be used at both KSC and VAFB and unless the schedules are coordinated conflicts may arise, particularly in the case of DOD's "on demand" launches. The conflicts may not be restricted to schedule but also as to vehicle.

RECOMMENDATION

Until such time as the KSC and VAFB sites have their own launch crews and dedicated Orbiters, the manifesting or scheduling activity should have a procedure to consider the schedule effects on crews who must travel back and forth. Also, attention must be given to the availability of specific Orbiters that may be required by specific missions. This is particularly critical in those cases where the DOD may be required to ask for an unscheduled launch.

8. Shuttle/Centaur

FINDING

The development of Centaur for Shuttle is on a very tight schedule. With but 30% of system weights being actuals, performance margins for the currently planned planetary missions are quite small and expected to decrease. Resolution of issues raised by some of the requests for safety waivers submitted by the Centaur project has not yet been achieved. This is a consequence of additional operational constraints introduced by the inclusion of abort modes for the Orbiter that do not provide the originally specified time for Centaur propellant dumping. There is also an issue concerning the interpretation of certain specifications for some Centaur fluid system components.

RECOMMENDATION

While acknowledging the fact that the issues are being addressed, the Panel urges that the matter of the safety waiver request and the interpretation of specifications be resolved with careful deliberation. The ability to make and incorporate significant design changes for Centaur G' within the time remaining to the planetary opportunity for Galileo is fast diminishing. With the major portion of the Centaur G' qualification test program remaining to be conducted, it would be highly desirable that the Centaur project staff be able to concentrate on insuring that the test requirements are met.

9. Radioisotope Thermoelectric Generators (RTG's) for Galileo and Ulysses Missions

FINDING

Both the planetary Galileo and solar Ulysses missions employ RTG's as the spacecraft power source. Obtaining clearance to fly such nuclear systems is a complex matter both technically and managerially. Relatively recently it was recognized that the capacity of the RTG fuel elements to survive overpressures that might be encountered under certain launch system failure modes might be less than had been anticipated. Concurrently, it was found that there were disagreements about the interpretation of experimental data used to estimate overpressures that would be generated for certain failure modes. Also, the probabilities of the several failure modes had not been agreed upon. During the last half of 1984 steps were taken by all organizations involved to resolve the issues in a fully coordinated manner.

RECOMMENDATION

The Panel endorses the proposal made by the ad hoc committee that addressed the issue to improve coordination among the organizations involved by appointing a "single point of contact" on this subject for each organization. Further, the Panel endorses the recommendation to assign prime responsibility for obtaining flight clearance to the science mission center, Jet Propulsion Laboratory (JPL).

10. NASA Aircraft Operations

FINDING

The record over the past year has been good. Progress is being made in providing up-to-date flight standards for both transport (administrative) aircraft and for experimental aircraft. Aircraft operations management resides in the Aircraft Management Office at Headquarters which reports to the Associate Administrator for Management. It is the Agency focal point for all NASA aircraft policy and related matters. The responsibility for development of flight standards is still somewhat fragmented as it is currently left to the various centers to establish and maintain them. The Aircraft Management Office has requested the Intercenter Aircraft Operations Panel to provide a "guidelines" document to serve as the basis for the management instruction to be issued by Headquarters giving central direction covering all NASA aircraft operations.

RECOMMENDATION

The Aircraft Management Office as the Agency focal point for all aircraft operations and related matters should include, if practical, an aviation safety function. The NASA centers would benefit by a single reporting location at Headquarters.

III. Panel Plans for Calendar Year 1985

Panel Membership

The Panel membership and consultant support has changed somewhat from the previous year. John C. Brizendine is the new Panel Chairman, Charles J. Donlan is a new member, Herbert E. Grier a former Panel Chairman and long-time member will become a Panel consultant in January 1985, and Lt. General Leighton I. Davis has elected to retire from the Panel in December 1984. A new consultant, John P. Reeder, has been brought on in support of Panel's "X" aircraft activities.

After completing 12 years as both a member and Panel Chairman, Herbert E. Grier, will become a consultant to the Panel on January 18, 1985 when his current term is completed. Mr. Grier's knowledge of NASA and its manned space program will continue to support Panel activities as the Space Transportation System transitions to full operations and the Space Station emerges as a full-blown program.

Candidates for membership are being screened at this time.

The following is a brief resume of Mr. Reeder:

Mr. Reeder started with NACA/Langley on June 2, 1938. Following 4-1/2 years of wind-tunnel research, he was trained by NACA/Langley as a research pilot and flew in that capacity with NACA/NASA for 25 years retiring after 42 years with NASA in 1980. He played an active role in the early development of handling qualities requirements for military and civil airplanes and the development of fixes and improvements to World War II aircraft. He performed early exploration of transonic phenomena pioneering in the exploration of the effects of sweepback and rotary wing and V/STOL aerodynamics, performance and handling characteristics. During this time, he flew transports for NASA/Langley and NASA Headquarters. He served as Head of Flight Operations, Assistant Chief of the Flight Mechanics and Technology Division, Chief of Research Aircraft Flight Division, and managed the Terminal Configured Vehicle Program. Research pilot experience include 235 different single and multi-engine, civil and military, land and sea aircraft types (40 jet airplanes, 40 fighter types, 61 rotary wing types including British, French and German, and 8 VTOL airplanes).

Mr. Reeder has been author or co-author of about 80 NACA/NASA technical reports and papers and is a Fellow of the Society of Experimental Test Pilots, a Fellow of the American Institute of Aeronautics and Astronautics (AIAA), an Honorary Fellow of the American Helicopter Society (AHS).

Panel Activities for 1985

Specific areas of interest will include the following. These, of course, may be modified as the fact-finding activities develop and as new concerns are brought to the Panel's attention from within NASA as well as external sources:

1. Space Transportation System - The Panel will continue to assess Orbiter structures and functional subsystems; External Tank (only if significant modifications are made to it); continued review of all aspects of the Space Shuttle Main Engine program; Shuttle Processing Contractor/NASA progress at KSC and VAFB as the flight rate increases, hardware ages and a new launch site becomes operational (design modifications to launch facilities to accommodate increased Filament Wound Case/SRB excursions, Centaur integration, bringing the second launch pad into operation at KSC); human factors associated with increased flight rates; Solid Rocket Booster steel case reuse, Filament Wound Case qualification for flight, range

the FWC, and the potential use ot hybrid cases, i.e., mixed FWC and steel. From a logistics viewpoint the Panel expects to look at:

- The problems associated with obsolescent parts.
- Adequacy of the publications with regard to such things as the correct reflection of the configurations of each individual Orbiter and the incorporation of the data gained from trouble-shooting experience.
- The plans to assure spare SSMEs and/or spare high pressure fuel and oxidizer turbopumps to cope with anomalies or use of higher thrust levels.
- The development of an overall comprehensive maintenance plan for the entire STS system including Orbiter and SSME overhaul up through 1990. Major structural and other modification programs projected for the Orbiter at Palmdale and engine overhaul and update at Rocketdyne would be part of this.
- Meeting or advancing the 1988 date for final "spares lay-in to support maximum flight rate" and what helps determine this, e.g., manufacturing lead times or limits of present funding?
- The possibility of transferring "sustaining engineering" activities from JSC to the operating bases at KSC and VAFB earlier than the 1989 period so as to support centralized control over operations.

2. Payloads - The several upper stages in so far as

they affect the mission safety. The Inertial Upper Stage (IUS) under USAF cognizance and the Payload Assist Motors (PAM's) a commercial development will be covered at a low level of activity. The Shuttle/Centaur G' and G vehicles and their support activities will continue to be reviewed. An area of some special interest because of the new and untried aspects is the Tethered Satellite System, as will be any internal/external experiments which can have an effect on safety of the STS missions (e.g., EASE, ACCESS and so on).

3. Space Station - As a developing program it is the Panel's intention to maintain close touch with the NASA organizations involved and, where practical, provide support and achieve a thorough understanding of the underlying concepts and philosophy and how they are expected to be implemented from both a management standpoint and technical approaches. For example, the degree to which "lessons learned" from NASA and commercial operations of highly technical facilities are applied. The evolution of the NASA organization and the relationships with industry will be of interest.

4. NASA Administrative and R&D Aircraft Operations - The Panel will again participate in the Intercenter Aircraft Operations Panel and aircraft safety meetings. Additional time will be spent on the X-29A program as it is flown by NASA personnel in an "X-type" R&D program. The X-Wing program will also be examined with an eye toward assuring that the review system and the safety network are adequate to assure not only first flight safety but subsequent R&D flying safety.

5. As appropriate the Panel will support NASA as it is requested to fulfill its obligation to both NASA and the Congress regarding safety of NASA activities and the public safety as well.

IV. Appendices

A. Panel Activities Conducted in Calendar year 1984

The Panel continues to operate with fact-finding sessions conducted on the average of three times a month. Individuals, small groups and the Panel focused on the transition period of the Space Shuttle as the flight rate is being increased to meet user's requirements, the emerging Space Station program and various aspects of NASA's administrative and R&D aircraft operations. As always the Panel usually uses scheduled, special and on-going activities at government and contractor installations to minimize the burden placed upon those we meet with and, more importantly, to obtain the most current information and maintain an open communications line with all whom we deal with. The responsiveness of all levels of NASA and others has been most gratifying and shows an excellent working relationship.

The technical and administrative support activities provided by the Panel Staff Director continue to prove invaluable to the Panel in meeting its objectives through continuing in-depth knowledge of the many facets of NASA activities.

The Panel's relationships with the congressional committees and subcommittees and their staffs remains at an excellent level. This provides a feed-back system to assure that the Congress is aware of the Panel's activities and their results and that the congressional requirements are factored into the Panel's fact-finding sessions throughout the year.

AEROSPACE SAFETY ADVISORY PANEL FACT-FINDING SESSIONS, 1984

SUBJECT	SITE	DATE	MEMBER
Shuttle Turnaround Analysis Group	KSC	1/17-18	Parmet
Intergrated Logistics Panel	KSC	1/25-26	Parmet/ McDonald
Flight Readiness Review for STS-41B	NASA HQ, Downey	1/25	Donlan, Grier, Himmel
Members of Computer Failure Review Team	NASA HQ	1/30-31	Battin
Orbiter Stability & Control	LaRC	1/31-2/1	Davis, Donlan
Annual Meeting w/Administrator	NASA HQ	2/15	Panel
House Testimony	U.S. House of Representatives	2/23	Panel
Senate Testimony	U.S. Senate	2/28	Panel
Space Station Human Factors Meeting	ARC	2/27 - 3/1	McDonald
Space Processing Contract	KSC	3/5-7	Parmet, Stewart
Phase II Shuttle/Centaur Safety Review	JSC	3/13-15	Himmel

Flight Readiness Review for STS-41C	NASA HQ & RI/Downey	3/30	Brizendine, Grier, Donlan
Filament Wound Case Rocket Motor Technical Interchange Meeting	MSFC	4/4-6	Donlan
NASA Aviation Safety Officer's Meeting	Ft. Rucker AL	4/11-18	Davis
Abort, Orbiter Handling Characteristics, Autoland, Space Adaptation Syndrome, JSC Aircraft Operations	JSC	4/24-26	Panel
Integrated Logistics Discussions	NASA HQ	5/2-9	McDonald
NASA Aircraft Operations	ARC	5/3-5	Davis
Safety review on airborne & ground hazards/risk, Critical Design Reviews, Centaur	General Dynamics, San Diego	5/8	Elverum, Himmel
SSME Project	RD/Canoga Park	5/10	Elverum, Himmel
Shuttle Autoland Discussions	JSC	6/8	Battin
Filament Wound Case for Solid Rocket Motor Technical Review &	Hercules/ Thiokol	6/19, 20, 21	Panel

site inspection			
Space Shuttle Main Engine Anomalies & future program direction	NASA HQ	7/11-12	Himmel
Orbiter Canards & Ditching	LaRC	7/31	Donlan
Panel Testimony	U.S. House of Representatives	8/2	Stewart, Donlan
USAF Space Transportation System Operations	VAFB, CA	8/21-22	Panel
Orbiter	RI/ Palmdale	8/23	Panel
Space Adaption Syndrome Seminar	JSC	8/31 9/1	Parmet
Space Station Orientation	JSC	9/25	Panel
STS Training & Simulations, Aircraft Operations	JSC	9/26	Davis, Battin
Shuttle Processing Contractor/NASA Operations	KSC	9/26	Brizendine, Donlan, McDonald
Centaur Project	LeRC	10/17	Himmel
X-29A Forward Swept Wing, Pre-Flight Readiness Review	DFRC	10/28 - 11/2	Donlan, Parmet

Panel Activities/ Discussions	Staff of the U.S. Senate & House of Representatives	10/30	Brizendine
Space Shuttle Main Engine Development Program Phase II, IIA	Rocketdyne Canoga Park	11/9	Elverum
Centaur Management Meeting	JSC	11/15	Himmel
Orbiter Life Cycle Certifiation Loads	RI/ Downey	11/16	Stone
Life Sciences	NASA HQ	11/29-30	Parmet
Update on STS, Space Station	NASA HQ	12/5-6	Panel
X-Wing Discussion	NASA HQ	12/17	Reeder, Krone

NOTE: Dr. Himmel was a member of a three-person Special SSME Review team visiting RD/Canoga Park, NASA HQ, and MSFC on a number of occasions.

B. Panel/Members/Consultants/Staff

Panel Chairman

Mr. John C. Brizendine, Chairman
Formerly President, Douglas Aircraft Company

Members

Dr. Richard H. Battin
Charles Stark Draper Lab.

Mr. Charles Donlan
Formerly, Dep. Assoc. Admin NASA HQ
Consultant, Institute Def. Analysis

Mr. Gerard W. Elverum, Jr.
VP & Gen. Mgr. TRW Space Group

Mr. Herbert E. Grier
Formerly, Senior VP EG&G Inc.

Mr. John F. McDonald
Formerly, VP TigerAir

Mr. Norman R. Parmet
Formerly, VP TWA

Mr. John G. Stewart
Ass't Gen. Mgr. TVA

Mr. Melvin Stone
Formerly, Dir. Structures
Douglas Aircraft Co.

Ex-Officio Member

Dr. Milton A. Silveira
NASA Chief Engineer

Consultants

Dr. Seymour C. Himmel Formerly, Assoc. Dir. LeRC	Mr. John P. Reeder Formerly, NASA Research Pilot

Lt. Gen. Leighton I. Davis
USAF (Ret.)

Staff

Mr. Gilbert L. Roth Staff Director	Miss Susan Webster Program Support Assistant

C. Panel Correspondence With Congress

There are items that come to the attention of the Panel which are considered valuable enough to warrant providing Panel comments and thoughtful considerations for congressional perusal. The letters which follow are typical of this type of correspondence. It is a part of the process noted in previous sections of this Annual Report noting the open forum, cooperative approach attached to Panel activities.

July 5, 1984

Honorable Slade Gorton, Chairman
Subcommittee on Science, Technology
and Space
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

As Chairman of the Aerospace Safety Advisory Panel I believe it is appropriate to comment to you and your Subcommittee regarding the auto shutdown of the Orbiter Discovery's main engines during launch sequence on June 26, 1984. The Panel believes it is particularly important to do so in view of the negative connotations in the media reporting of the event, which may have created misleading impressions in the minds of the public regarding the safety of the astronaut crew and the soundness of the Space Transportation System.

In fact, the system operated precisely as designed. The launch sequence was stopped automatically when the computer detected a mismatch between actual engine start function signals and the pre-programmed, required function signals. Thus this design safety feature performed as intended to ensure the safety of the crew and the vehicle system. This should bring positive connotations rather than negative ones.

We of the Panel view the Space Transportation System as a program still in transition from the development stage to the operational stage. Due to the nature of its missions and the necessary complexities of its hardware and software, the transition period will continue for some time into the future. It would be a misconception and an unrealistic comparison to expect airline-type operations from the Space Transportation System (although it can be noted that even sophisticated jetliners experience some departure delays and occasional cancellations for technical reasons). The important consideration is that each mission be carried-out safely and successfully. The Space Transportation System safety record is 100 percent thus far, and we are pleased to see the design performing to maintain this record.

Respectfully yours,

John C. Brizendine
Chairman
Aerospace Safety
Advisory Panel

September 14, 1984

Honorable Harold L. Volkmer
Chairman, Subcommittee on Space
 Science and Applications
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

I was pleased to substitute for Chairman John C. Brizendine in presenting the views of NASA's Aerospace Safety Advisory Panel at the Subcommittee's hearing on August 2, 1984, to review Space Shuttle requirements, operations, and future plans. In reviewing the transcript of the hearing, especially the discussion among William A. Anders, representing the NASA Advisory Council, myself, and subcommittee members, I was struck by what at times appeared to be the contradictory assertions that, on the one hand, the Space Shuttle should be viewed as a research and development vehicle for the duration of its operational life and that, on the other hand, NASA should move toward creation of an independent entity within NASA to manage Shuttle commercial operations since NASA's R&D centers were not well suited for this long-term operational responsibility. Given the importance of these roles and relationships for the future of the Space Transportation System, I thought it might be of help to the Subcommittee if I attempted to clarify this line of thinking. These are my personal views although I believe they reflect the general thinking of other Panel members.

In discussing continuing R&D as it relates to the Space Transportation System, several facts must be kept in mind:

1. Many of the original systems and equipment items--especially in the areas of general computers, avionics, and navigation--are obsolete and must be replaced or significantly upgraded.

2. Critical systems, such as the Space Shuttle Main Engines, the auxiliary power units, and the brakes, have performed below expectations and should be upgraded.

3. The complete flight envelope for the Orbiter has not been defined as yet and its definition may indicate the need for structural or other changes to the Orbiter.

4. The need for increased hardware reliability and reduced turnaround time is likely to dictate equipment and system improvements for many years to come.

5. A new generation of upper stages, principally the Centaur and the IUS, must be incorporated in Shuttle operations if the full capability of the STS is to be realized.

These facts indicate clearly why a continuing program of R&D is essential to the safe and efficient operation of the Space Transportation System. In other words, there is no way NASA could responsibly "freeze" all design elements at the present stage of STS maturity. As a consequence, Shuttle operations are not likely to resemble those of a commerical airline in the near future. To assume such highly predictable routine operations is to ignore the important R&D tasks still underway and the uncertainties that inevitably are part of any R&D effort. We can realistically expect elements of this R&D program to continue into the 1990s.

The Shuttle can also provide a useful "test bed" to evaluate various advances in space and astronautics in much the same manner as industrial R&D will be carried on in Spacelab and other missions. For this reason the Panel's statement at the recent hearing noted: "...the Orbiter itself is the only vehicle capable of negotiating the complete velocity and heating encountered during STS missions. This knowledge would help resolve current problems and point up future technical directions. The high technology information which would become available through its use would also be applicable to advanced commerical and military vehicle design."

In short, an adjunct R&D program focused principally on upgrading the operational characteristics and reliability of the Space Shuttle is essential. This program in my view, can be directed most effectively by an entity within NASA charged exclusively with commerical operation of the Space Transportation System. Such an entity, discussed by William Anders and myself during the question and answer period, has been recommended by the Panel in our last two annual reports. NASA has taken several initial steps in this direction.

This operational entity must necessarily draw heavily upon the scientific and engineering expertise of the NASA R&D centers in much the same way that NASA uses outside contractors. However, the R&D agenda maintained by the operational entity would reflect those task related to improved operations, rather than the much wider agenda of innovations that could be supported by the R&D centers relatively free of the discipline of commerical operations. The perspective is one of fundamentally accepting the Space Transportation System as it presenty exists, subject only to the improvements and changes discussed earlier in this letter.

As we noted in our testimony, even an R&D agenda focused on such operational priorities will be substantial and will require considerable funding support in the coming years. This R&D program will move the STS steadily in the direction of greater reliability, greater cost effectiveness and enhanced safety. It will help bring to full operational maturity the world's first reusable space vehicle and set the stage for the next generation. This essential work, in my view, can be directed most effectively by an entity within NASA that has achievement of this operational maturity as its principal mission.

I hope these additional views are of assistance to the Subcommittee in its important review of the STS. If I or other members of the Panel can be of further help, please do not hesitate to call on us.

Sincerely,

John G. Stewart
Member, Aerospace Safety
Advisory Panel

D. Fact-Finding Results in Calendar Year 1984

1. Space Transportation System Launch Processing and Logistics

While the Space Transportation System (STS) in 1984 demonstrated its unique versatility and usefulness in space through a number of highly successful missions, its problems (e.g., tiles, engine changeouts) on the ground continued to challenge NASA management, the R&D centers, and NASA contractors, especially those responsible for launch processing. Launch and landing operations encompass activities at KSC, VAFB and the many secondary and contingency landing sites as well as reaching into the development centers and their contractors. The Panel has focused on the developmental aspects of the program affecting the management needs of the current period, the hardware/software requirements, resource needs, and the integration of STS operations from the factory to the launch and landing sites. The ultimate management form and the means to achieve it are under study by NASA with no definite approaches as yet selected. Some points, however, have emerged:

- There must be no disruption in the operational support adequacy and ability to safely launch and turnaround the Space Transportation System as currently operating.

- Personnel are a key resource and provisions must be made to "feed in" new people to replace, as necessary, those leaving.

- Hardware and software, as required, will require updating and replacement owing to obsolescence, aging or inability to obtain replacements.

- Traditional organization arrangements, review methodology, handling of payloads, and system certifications cannot remain static but will change with STS maturity and accompanying knowledge and objectives.

- Complacency at any point in the process must be guarded against.

- A specific aspect of the management process which bears further attention are the "Program Freeze Points" and their use. Program freeze points are established at specific intervals during flight processing. Freeze points are defined as those points in time when the design, definition, and content of the cargo, integration hardware/software and flight design, vehicle flight hardware/software, crew activities/stowage and launch site flow are complete. Subsequent to these points, only mandatory changes to the hardware, software or affected documentation are permitted (mandatory changes are those necessary to ensure crew/vehicle safety and/or accomplishment of primary mission objectives). Such freeze points are established for each mission.

- Preparations for contingency landing site (CLS) activities must be planned to meet mission goals and to minimize expenditure of resources which can best be used elsewhere.

- Operational efficiency as measured by such things as turnaround time reduction, hardware increased reliability (increased mean time between failures), increased crew effectiveness, weather predicting, are all a part of operations. Since Day-of-launch winds can affect vehicle aerodynamic loads, better trajectory shaping and load reduction can be accomplished with winds as near to T-0 as possible. The actual "doing" part of launch and landing along with retrieval of SRB's has been proven through the fifteen STS missions to date. However, one area of continuing interest is the impact of flight vehicle and ground equipment hardware and software changes (both generic and mission unique) and procedural changes upon the ground sites, including modifications to the launch constraints or so-called "red-and-blue lines." With regard to any of these the safety impacts continue to be analyzed covering such things as:

- Hazard analysis if a hazard is defined. This includes evaluation of single failure points, redundancy, interaction between "improvement" and interfacing hardware/software/procedures/facilities.

- Many enhancements are to eliminate and/or downgrade current hazards, i.e., accepted risks and controlled hazards.

- The human element, particularly with respect to launch preparations and the turnaround itself, require inspection of "hands-on" impacts which may lead to additional training requirements.

Each mission has provided a more substantial level of experience upon which residual design limitations are being corrected. Significant operational enhancements are being studied for eventual implementation for both mission use and turnaround time optimization. A concerted "lessons learned" exercise is underway with NASA, the SPC, R&D centers, and development contractors to understand and correct the management and engineering problems encountered in launch processing. These commendable actions underscore the developmental nature of the programs at present. This period of "evolutionary maturation" is likely to run to the latter years of this decade. In this regard, a number of developmental aspects of the program are of continuing interest:

o There are a number of hardware items, especially in the avionics arena, that are obsolete and must be replaced or significantly upgraded. Attendant software impacts would, of course, depend upon the equipment. Included here are brakes on the Orbiter which consistently have performed below expectations.

o Achieving the desired Orbiter/stack flight envelope requires further loads definition and Orbiter structural analyses.

o Maintaining and increasing hardware reliability (life) remains a significant part of the program plan and is likely to dictate equipment and system ground and flight improvements for many years to come. This includes the reliability and safety of the so-called "upper stages" which although technically called "payloads" are integrated into the Shuttle operations.

It is reasonable to expect variances and adjustments to plans and timetables based on the above considerations and consequently STS operations are not likely to resemble those of a commerical airline. There is, then, no practical way to "freeze" all of the design elements in the future.

It has been the Panel's opinion for several years that this multi-faceted management challenge would be met most effectively through creation of a STS operations entity to assume overall direction of these developmental and management activities, using the R&D centers in much the same way that NASA draws on the expertise of its development contractors. (See, for example, the letter of Panel member, John G. Stewart to Honorable Harold Volkmer, U.S. House of

Representatives, September 14, 1984 in the Appendix C.)

A complementary area of interest is the pre- and post-flight mission reviews. The Panel notes, as it has in the past (see Annual Report dated January 1982 and January 1983), that the management review processes remain little changed from those used on early missions. With an increased flight rate, maturing systems and hands-on resources, there remains the involvement of a large number of high level management personnel. Changes made to date in this review system have certainly helped but further streamlining should be expected in the future.

Very encouraging progress is evident in gaining control of the complex overall logistics program. The Integrated Logistics Panel (ILP) and its dependent coordination meetings appear to be gaining satisfactory control of the problems. Cooperation between USAF personnel at Vandenberg and NASA personnel at the JSC, KSC, and MSFC centers appears to be excellent and the overall efforts have regained a lot of lost time.

The Panel has previously recommended that a comprehensive maintenance plan be established partly as a system to prevent interruptions in the launch rate through the 1990 period and beyond and partly to provide a more rational basis for the current logistics plan which is now under way. While some elements of maintenance planning are evident there does not yet appear to be a total plan which would include contingencies such as multiple SSME failures or planned withdrawal of an Orbiter for structural fatigue examination or replacement.. This sort of maintenance overview may indeed exist and will be examined by the Panel in the future.

The SPC in its operations has uncovered some problems; the most serious of which is shortage of spares. Line replaceable units (units designed for rapid replacement) are in short supply and the only alternative is to "cannibalize" - that is to remove a working component from another Orbiter and pay back the loan when the part becomes available. This is a costly procedure in terms of manhours and delay but the safety implications are those of violating a certified system to get the necessary parts. Another significant problem is that of the workload caused by the incorporation of modifications on the Orbiter at KSC. Even though modifications are scrutinized before the decision is made to incorporate them, further controls may have to be instituted if the launch rate requirements are to be met. The next year or so should see some improvement in logistics and support problems as the SPC program advances satisfactorily.

If OV-105 is ever funded it will have the beneficial effect of providing a "standby vehicle" in the Orbiter fleet but at the same time will sop up most of the available "production spares" thus exacerbating the problems surrounding each individual launch toward the 1990s. The goal is presently some 20 flights per year from KSC and 4 per year from VAFB. There has been a sizable transfer of experienced personnel from KSC to VAFB and we were told that there are about 1200 LSOC people there now.

One of the greatest impediments to rapid turnaround time at KSC - apparently second only to shortage of spares - is the continuing need for modifications. It is true that every modification requirement is most carefully scrutinized by various engineering committees but the cumulative effect of all of these, together with the poor-fit difficulties, is causing considerable distress at the launch site. This entire issue goes back to the question of major overhaul, maintenance planning and the inevitable backlog of modifications will constitute a pacing element. Not much "on-line repair" is being accomplished at KSC which again points out the need for a more definitive maintenance program.

Clearly, the decision has already been made not to include the logistics, supply and support elements of Spacelab, Shuttle/Centaur, Inertial Upper Stage and Payload Assist Module in the ILP considerations. However, it still appears that while funding and control of logistics are separate issues the apparent "hands-off" attitude could well result in launch delays unless they are well stocked with spares. The importance of avoiding launch delays because of payload problems is as important as preserving the logistics support integrity of the STS itself. It is, after all, a system and launch delays have sequential effect upon downstream program where only one launch pad is operational.

2. Space Shuttle Main Engines (SSME's)

The accumulated data on SSME turbomachinery has made it amply clear that the engine is being operated near the upper limits tolerable to the design, and that margins are not sufficient at 109% of nominal power to permit reuse without frequent (every other flight) change out of various turbopump components. This situation is relieved by limiting normal flight operation to 104%. However, even at 104% the engines still have displayed a variety of random wear and damage problems partly associated with design inadequacies and partly associated with manufacturing and maintenance quality issues.

At the end of 1983 a Three-Phase Program was undertaken at Rocketydyne to systematically address these issues. The Phase II and Phase III parts of the program were well-planned to understand the operating limits and to analyze and correct the stressing areas. The basic goal of the program was to improve the operating limits for components showing less than 5000 seconds at 109%, but also in reality to provide improved margins at 104% for higher flight confidence and lower-cost maintenance.

The focused goals of Phase II were to:

o Increase the HPFTP turbine temperature redline margin from 140°F to 250°F by: improving the HPFTP efficiency, and reducing the turbine back pressure

o Eliminate the turbine sheet metal cracks

o Increase second stage blade life on both the HPFTP and HPOTP

o Increase first stage blade life on HPFTP

o Correct the liftoff seal bypass leakage problem of the HPFTP

o Improve rotor stability on HPOTP to increase whirl margin

o Improve bearing life of the preburner pump and turbine of the HPOTP.

The Phase II program was fully reviewed by some of the Panel members in late 1983 and again in May and November of 1984. The progress made by November 1984 has been impressive. Significant improvements have been made in both the HPFTP and HPOTP. Of real importance however is that in many of the problem areas new fundamental understanding of design criteria have been achieved so that the changes in certain areas represent different and lower-stress operating regimes.

For example, the 500-RPM FPL margin on whirl on the HPOTP has been increased to almost 7000 RPM. This effectively eliminates the problem and provides a known high margin. In another case, a new understanding of the dual turbine bearings dynamic load transfer has resulted in new clearance criteria and reduction to a 12 ball bearing from 13 balls. The reasons for the wear initiation and surface degradation are understood, and the new design clearance provides acceptable operation at all conditions within the designed ball excursion vs radial pre-load region. These and other basic improvements in turbine blade configuration and coatings, welding criteria, etc., have provided a configuration for a new certification program starting in early 1985.

About mid-1984 the Phase III program was eliminated by NASA. It was replaced by a much restricted Phase II+ activity and a longer range technology oriented Advanced Development program. The very limited Phase II+ program does not address most of the items identified in the 1983 Phase III Plan. The only significant change planned for certification is the new hot-gas manifold (HGM), and that HGM will not be introduced into the fleet until about CY 1988. Other key elements of Phase III will be evaluated in a "Precursor" portion of the Advanced Technology program. The elements include single tube heat exchanger with no internal welds, a large throat diameter main combustion chamber and advanced design turbomachinery. Since the "Precursor" program is technology-oriented only and very funds-limited, it is clear it will not really permit timely introduction of the major changes in turbomachinery nor large-diameter Main Combustion Chamber necessary to provide the desired final operating margins at 109%. Although major progress in operating life of components was achieved in the Phase II work, this really relates to replacement cycle-life and not to the environment reductions critical to increasing margins which were planned for Phase III. It is our judgement, therefore, that the SSME should continue to operate with the 104% limit to the greatest extent possible. This will assure that the gains in changeout time are maximized with the attendant cost savings, and that margins are satisfactory for flight reliability.

Only after the Phase II+ and Precursor modifications, particularly the large throat chamber are certified will the goal be achieved of providing operational environments and margins at 109% equal to those now extant at 104%. When that is accomplished one can designate the SSME upgrade as a rated-power engine of 109% of the original rated power level.

Another aspect of the engine improvement process is the desire on the part of NASA to inject a provision for competition into the large liquid rocket field. This is being pursued through advertised requests for proposal on various aspects of the SSME program (i.e., using the current nozzle, engine controller, low pressure pumps and such with new powerheads and high pressure turbomachinery). The idea appears to be that the SSME would be designed to operate at 115% thrust with full life, 30 missions certified with 60 missions demonstrated, and would be capable of operating at, say, 120% thrust with reduced life and being able to throttle to 50% (which can not be done with current engine). Further, with changes to the low pressure pumps and with the same high pressure pumps, there is a possibility of growth to a 130% thrust engine. All of this would require about 8 years for fruition and actual flight use.

3. Space Shuttle Solid Rocket Boosters

The interaction of the Filament Wound Case (FWC) with the total STS stack may cause liftoff loads and vehicle excursions to be in excess of the launch mount capabilities at KSC or VAFB. Even though the loads may be controlled by the use of Belleville spring mounts in the hold-down post at VAFB it still may be more critical than KSC.

The SRM filament wound case segments have already been produced for flight, development and qualification units.

Analysis has been performed using scale model tests to predict modes and frequencies. However, it will take a full scale test to measure vehicle deflections accounting for the FWC joint free-play.

The twang test scheduled for January 1985 derives influence coefficients for primary bending, but does not predict the secondary modes and frequencies during firing and lift-off. It may be possible to calculate or test for the effect of FWC joint free-play and account for secondary modes and frequencies, but it may be worthwhile to measure actual deflections during an SSME firing to provide assured data.

The Panel is concerned about the tight limits placed on the current schedules.

4. Orbiter Structural Adequacy and Life Certification

The Orbiter OV-099 was statically tested for 32 load cases to approximately 1.2 times limit loads (ASKA 5.4 loads cycle). Approximately 33 fatigue/fracture/acoustics supplemental test articles have been completed successfully, except for one which will be completed shortly, in accordance with the certification plan. A scatter factor of four was used in these fatigue and fracture tests. It was decided to delete two tests because of cost and negligible damage shown by analysis due to the fatigue spectra. For instance, tension stress in the lower wing skin is approximately 30,000 psi. The Orbiter is designed for 100 missions whereby a commercial transport is designed for 50,000 flights. The one article, "LI 31", outboard elevon/flapper door/wing portion of rear spar has been tested to 100 missions of acoustic fatigue as test WA-18. The mechanical fatigue and ultimate design load conditions have not been tested. The specimen is now in storage.

The other article, "LI 36", wing/mid-fuselage/aft-fuselage has not been tested for fatigue, ultimate design loads or acoustic environment. The specimen will be put into storage. In this case, the fatigue is negligible, acoustic loads small; however, ultimate strength will not be demonstrated. It is the Panel's opinion that the test of one wing with a simulated carry-through structure is not representative of the wing-fuselage intersection inboard of wing station 167.

It is therefore recommended that these two articles be certified by analysis.

Orbiter Wing and Fuselage Modifications Status:

The Orbiter OV-099 and OV-102 were designed to the early ASKA 5.1 loads. The Orbiter OV-103 and OV-104 were designed to ASKA 5.4 loads with weight savings incorporated only where loads were lower than ASKA 5.1 loads.

The flight test data from flights STS-1 thru STS-5 showed that the wing loads were larger and more aft than design loads during ascent requiring wing modifications at Xo 1191 and wing spar modifications on OV-103 and OV-104.

Leading edge moment-ties were required on all Orbiters due to the increase in down loads in changing the trajectory to more negative $q\alpha$ (dynamic pressure x angle of attack). Mid-fuselage straps were required on all Orbiters due to stringer torsional instability caused by higher thermal gradient during descent. Beef-up of 1307 bulkhead was required on OV-103 and OV-104 due to higher delta pressure. Beef-up of 1307 bulkhead on OV-099 and OV-102, which did not incorporate weight savings, will be decided by further analysis.

Current algorithms derived from flight test data using load indicator gauges defined the increase in wing loads during ascent more precisely resulting in a new package of wing modifications. These modifications include upper wing panels, rib caps, internal and wing/fuselage carry-through structure, fittings and bolts. This package of work is sized for a nominal $q\alpha$ of -2500 but may have to be changed to $q\alpha$ of -3000 if all the modifications can't be accomplished in accordance with required schedules.

Table number one shows the status of Orbiter, wing and fuselage modifications. These modifications will not allow a nominal $q\alpha$ of -1250 to be attained as originally planned therefore further modifications may be required at a later date.

ASKA 6.0 Loads/Thermal/Stress Cycle:

The 6.0 loads/thermal/stress cycle program is proceeding on schedule. The flight measured data are being incorporated into the analysis data base using ascent aerodynamics, ascent loads, descent aeroheating and descent thermal analysis. The large protuberances, Orbiter shape and trajectory regimes have made it difficult to predict wing loads and its distribution within 20 to 30 percent.

The aerodynamic data base used wind tunnel analysis, cold plume simulation and Apollo-Saturn Launch Vehicle fit experience. However, the flight test data showed plume effects larger, normal force larger and more aft, higher local pressures and left/right wing differences.

Operational flight data has been used to check ascent aerodynamics, descent aeroheating and thermal analysis to optimize trajectory shaping, make recommendations for launch and is used to complete the 6.0 loads/thermal/stress cycle. The 6.0 environment, basic math model development, entry external flight loads and landing loads are nearly complete with final data including ascent flight loads available February 8, 1985 for entry into internal loads model.

The internal loads analysis will be available September 15, 1985 with stress analysis margin of safety results available March 15, 1987 and final report August 15, 1987. OV-102 instrumented flight data available in early 1987 will verify the data base used.

Wing airload (predicted pressures) using flight strain gage data shows increase in pressures at upper wing and lower wing station $Y_O=250$. This explains why normal loads are larger than design ASKA 5.4 loads. The flight-derived wing indicator gages show excellent predictive capability for shaping trajectories.

Aeroheating/thermal analysis using updated thermal math model shows good correlation with flight data although it is slightly conservative. Temperature gradient predictions are still a problem.

6.0 loads/thermal/stress cycle is proceeding according to plan but can't be accomplished in less time than scheduled. Final verification of data base used for 6.0 analysis will be available from instrumented OV-102 flight data in early 1987, which may require adjustments to the 6.0 loads/thermal/stress analysis.

TABLE 1

ORBITER WING & FUSELAGE MODIFICATIONS STATUS

ORBITER VEHICLE	OV-099	OV-102	OV-102	OV-104
Design loads cycle	5.1	5.1	5.4	5.4
Thermal Protection System Configuration	LRSI/HRSI	LRSI/HRSI	AFRSI	AFRSI
Wing Mod's (1)	Not Req'd	Not Req'd	Req'd	Req'd
Wing Spar Mod's	Not Req'd	Not Req'd	Req'd	Req'd
Wind Mod's (2)	Req'd	Req'd	Req'd	Req'd
Leading Edge Moment Ties	Complete	Req'd	Complete	Complete
Mid-fuse, Straps	Req'd	Req'd	Req'd	Req'd
1307 Bulkh'd	Analysis	Analysis	Req'd	Complete
Instrumentation	Complete	Remain Sched. (1985)	Sched. (1985)	Sched. (1985)
Missions	Ulysses/ Centaur (5/86)			Galileo/ Centaur (5/86)
Major Mod's	KSC	Palmdale 6/84 to 1/85 Many syst chng		Palmdale (Comp 12/84)

(1) Xo 1191 crawl hole doublers & wheel well beef-up

(2) Wing cover, ribs & internal structure

LRSI = Low temperature reusable surface insulation
HRSI = high temperature reusable surface insulation
AFRSI = Advanced felt reusable surface insulation

5. Space Extra Vehicular Activities (EVA's) and Lite Sciences

EVA's are becoming a normal part of the STS mission time-lines in support of repair, maintenance, retrieval and specific scientific and technical experiments.

As evidenced by the many and varied EVA operations during 1984 there appears to be no problem with the current methodology which includes the reduction in cabin pressure from 14.7 psia to 10.2 psia hours before donning the suits which are then pressurized to 4.3 psia (pure oxygen). The return is accomplished in the same manner. Space Adaptation Syndrome (SAS) still appears to be a problem for a majority of the crews and may even have affected, for some period, those doing EVA work. It is apparent that the crew training for EVA is thorough, and certainly covers the work to be done each time in meticulous detail, which provides for safety as well. The Extravehicular Mobility/Maneuvering Unit (EMU) or space suit, has instrumentation necessary to status EVA operations. There is some question in-house as to the value of additional instrumentation or enhancements that would allow EMU consumables resource status in order to assess new EVA task and procedures for optimization. Such implementation would require measurement of a few new EMU parameters and telemetry of these new parameters along with some currently measured parameter to a central recording and analysis point. These data could allow understanding of task and procedures design as they affect man's integration into the EVA workplace. Specific parameters to be telemetered include Liquid Cooled Garment inlet and outlet temperatures, O_2 bottle pressure, suit pressure, electro-cardiography, battery power remaining, limiting consumables and possibly others. Some can be obtained through derived parameters such as heart rate and LCG temperatures. We believe this instrumentation would allow the accumulation of a much needed expanded empirical data base.

6. Use of Orbiter 102 in an R&D Role

The Shuttle, despite being pronounced "operational" by NASA after its fourth flight, is far from being "operational" in the sense that term is commonly understood in the airline industry. Many thousands of test flight hours are normally accumulated on a commercial airplane before it is finally certified for routine commercial service. The Shuttle was declared "operational" to announce its availability as a payload carrier vehicle although it is far from "operational" insofar as its measured structural and aerodynamic characteristics are known. For example, wing loads are not yet symmetrical and somewhat higher in certain areas than predicted. Consequently, until more complete flight data is available, Shuttle ascent and descent trajectories must be tailored conservatively to avoid overstressing. If the Shuttle is to attain its maximum performance goals, far more extensive flight data is needed than is now available. Orbiter 102 is the most completely instrumented vehicle of the fleet and is capable of providing the needed data when used as an R&D vehicle. There may be times when it would be worth giving priority to this role over more routine missions. In past flights, data have been lost because of instrumentation system failure. It is suggested, therefore, that because of the small number of flight opportunities the instrumentation (particularly recorders) should be redundant to guard against loss of data in the event of failures.

6a. Use of Canard Surfaces to Reduce Orbiter Landing Speeds and Enhance its Stability

Langley Research Center conducted studies of the use of canards on the Orbiter. As expected the canard configuration does eliminate the undesirable negative lift increment using the current elevon design. The investigations were somewhat limited and did not go into a great number of combinations of Orbiter angle of attack, canard angle of attack, surface areas, and other effects. It would represent a major configuration change requiring years of research and development effort. The Panel is sympathetic with the reluctance of the Shuttle Program Office to undertake such a development when simpler modifications are in the offering. For example, it is the Panel's understanding that the DFRF "TIFS" (Total Inflight Simulator) is to be used to explore some modifications to the Shuttle control system that earlier studies at Ames Research Center indicated could improve the handling qualities by decreasing the pilot induced oscillation (PIO) tendency.

7. KSC and VAFB Common Operations

For some substantial startup time -- years not months -- the rate of Shuttle launches from VAFB will be too low to justify the establishment of a complete launch crew that would be inactive for most of the year. The present plan is to use selected military personnel that have had training at KSC as permanent VAFB personnel and at each launch move the rest of the required crew from the NASA ranks at KSC. None of these people have had the opportunity to train at VAFB and hence the crews must be in residence some appreciable time before each launch, most particularly before the first launch at VAFB.

While this would seem to be a straight forward scheduling job it is complicated by two facts. First, the DOD may be required by circumstances to ask for an unscheduled launch on short notice. Second, the Orbiters are not identical from a structural load capability and certain loads may require certain Orbiters. The scheduling problem is not bad if one formally identified it and is aware of the limitations it may impose on the joint operations. A subsidary but important point is that the launch crews have not trained at VAFB nor has the facility been exercised. The Panel has recommended that an FRF be conducted at VAFB prior to the first launch as a facility and crew certification. A bonus to such a test would be a partial insight into the "Twang" effect on the stack under the VAFB hold-down conditions.

Common ground support equipment interfacing with the space Shuttle vehicle requires special attention so that consistent functional design and such interface characteristics are rigidly maintained since loss of configuration commonality may occur due to KSC or VAFB programmatic requirements.

8. Shuttle/Centaur

The development of the Centaur G & G' stages is progressing only slightly behind schedule. Some changes in interface loads have resulted in redesign of parts of the Centaur. This had contributed to the small performance margins for the G' stage for the planetary missions with but 30% of the Centaur systems weights being based on actual hardware. It is anticipated that further reductions in margin will occur.

Significant progress has been made in the development and qualification test programs although the bulk of the program remains to be accomplished. Among the tests completed are the acoustic test of the G' forward and development adapters and the structural stiffness and 1.2 x limit load tests of the Centaur support structure (CSS). In both of these tests design assumptions were verified.

Preparations are well under way for the major systems tests. These include: test of purge and insulation systems; all-up structural tests of the CSS, tank, adapters and spacecraft mass model under cryogenic conditions, and a modal survey test of the stack just noted.

Electronic systems tests have progressed reasonably well. Some units have completed qualification tests. All Design Evaluation tests (to qualification environmental levels) have been completed satisfactorily. Formal qualification has been delayed because of problems in the procurement of electronic parts and devices.

Three requests for safety waivers had been submitted to the Shuttle Program Office. Two have been approved. The third, dealing with the Centaur fill, drain and dump systems is still under consideration. This system was designed to a requirement that it be able to dump all Centaur propellants in 250 seconds in the event of a Shuttle abort. Since that requirement was established, Orbiter abort modes which do not have 250 seconds available for propellant dump have been identified. The implications of the situation are being assessed. Design changes or operational changes to mitigate the problem are under discussion. The time available to implement any changes is limited because of planetary launch opportunity constraints.

9. Radioisotope Thermoelectric Generator (RTG)

The Panel is aware of issues associated with the Radioisotope Thermal Generator (RTG) to be used on the Galileo and Ulysses spacecraft. The concern is with the possible spread of radioactive material if there is a catastrophic destruction of the SRB's and ET's during pad or ascent phases, or during a landing as the result of an aborted mission. The Panel has not had a review of on-going activities except to note that they are many and diverse in nature. Suffice it to say that the Panel believes that adequate management and technical attention is being paid to RTG concerns.

10. NASA Aircraft Operations

NASA has been long concerned with safety of operations for program support and R&D aircraft. To meet the challenge posed by a "zero accident" desire, the NASA Administrator called for "an action plan that will result in standardized and consistent policies and guidelines to the centers." Such a plan has been developed by the NASA Headquarters Aircraft Management Office and is in process of implementation:

Step 1. Revise and publish the NASA Management Instructions (NMI's) that give guidance for the management of aircraft resources and aircraft related matters (7910.1), that establish policy and guidelines for airworthiness and flight readiness reviews (7910.2), and that govern the management and operation of NASA administrative aircraft. Step 1 was completed in September 1984.

Step 2. Revise and publish volume 7 of the basic safety manual (NHB 1700.1) to provide a step-by-step procedure for use to perform safety hazard analyses. It is planned to send this revision to the centers for comment by June 1985.

Step 3. Cause to be published a memorandum for each Program Associate Administrator having line reponsibility over centers with aircraft directing the implementation of certain policies and procedures which have been established by Headquarters but to date have received limited acceptance by some centers. This step was completed in October 1984.

Step 4. Formalize the policies in step 5 through the publication of a management instruction. Target for completion of the instruction is October 1985. A draft will be ready for review at the February 1985 meeting of the NASA Intercenter Aircraft Operations Panel.

Step 5. Continue to conduct periodic reviews of the center aircraft operations to improve safety. Periodic review of each center's flight operations is ongoing.

The NASA Intercenter Aircraft Operations Panel, composed of the Heads of flight operations at the various centers continue to play a major role in the area of safety assurance. This Panel reports to the Associate Administrator for Management and provides the technical guidance required to centrally manage the diverse missions comprising NASA's flight operations. The Aviation Safety Officer meetings continue to be held to provide concentrated interchange of safety related information. For purposes of repeated emphasis the Panel is particularly interested in two areas affecting accident causes and investigation: human performance, including sensation, perception, cognition, judgement or reactions produced that leads to degrees of human performance; secondly, instrumentation which may be available in case of aircraft problems.

We plan to monitor the X-29A project through its early phases of flight testing. This includes attending appropriate sessions to observe and participate in the evaluation flight test results and future vehicle testing. Plans are to fly the airplane within a limited flight envelope until early May 1985 when the airplane will begin two months of downtime to receive an updated flight control system prior to resuming further flight testing.

New technology items of interest include:

1. Thin super critical (4%) wing with forward sweep.
2. Aerolastic tailoring of wing with composite stressed skin.
3. Relaxed static stability of minus 35%.
4. Close coupled canard with variable incidence.
5. Three horizontal control surfaces, canard wing and strake.
6. Discrete variable camber wing.
7. Triplicated digital flight control system.

E. NASA's Response To Panel's Annual Report Covering CY 1983

The following document, dated August 30, 1984, is the complete letter responding to the Panel's Annual Report dated January 1984. Those items of continuing interest to the Panel are noted in Section I, Executive Summary.

AUG 30 1984

Mr. John C. Brizendine
Chairman, Aerospace Safety
  Advisory Panel
6306 Bixby Hill Road
Long Beach, CA 90815

Dear John:

In response to the ASAP's Annual report to NASA, JSC provided the Panel with an in-depth briefing on April 24-26, 1984, on those programmatic and technical issues which the Panel had raised. This in-depth review closed a number of actions, and for some issues the approach to resolve them was presented. This letter presents a top level overview of the status of those issues raised by the Panel and our plans for those areas still open.

As you are well aware, I rely heavily on the Panel's counsel, and I wish to iterate our appreciation. If further information is required, please contact me.

Sincerely,
Original Signed by
James M. Beggs
James M. Beggs
Administrator

Enclosure

1. Product Quality and Utility

ASAP Recommendation:

NASA and contractor employees, both design and production, should now be looking at hardware improvements with operational suitability rather than increased performance as the dominant goal. NASA should give added attention in assisting contractors and subcontractors to achieve high quality products oriented toward such operational suitability.

NASA Response:

I believe that the Panel addresses two subjects in the conclusions and recommendations for product quality and utility, namely, motivation and changes to enhance operations. I totally support the Panel's position on the need to emphasize motivation of the Space Transportation (STS) design team to yield the highest quality product oriented toward operational suitability. To be effective, such an effort must originate with senior management. To emphasize my commitment to quality production, I have established the position of Director of Productivity in the Office of Productivity Improvement and Quality Enhancement. I have personally addressed numerous groups and also have prepared a video tape for use by our subcontractors. We established the NASA Productivity Steering Committee, that I chair, which has Headquarters Associate Administrators and Center Directors as members. Our objective is to examine NASA policy and fundamental changes to improve operations. Our first meeting was held at MSFC on April 26-27, 1984. The conference was attended by more than 200 persons including representatives from 50 different aerospace companies. Our goal is to arrive at new approaches and initiatives to enhance the productivity of NASA and its contractors. Along those lines we have implemented a quality circles program at Headquarters, called NASA Employee Teams (NETS), and at the field centers. They are also in operation at practically all of our major contractors.

Reports so far indicate that the centers and their prime contractors have enthusiastically taken to this initiative. As an example, Level II at JSC has recently issued a directive to all their projects requiring field reviews of hardware to determine the occurrences of unknown failure modes and premature wear, thereby checking qualification and verification program results. The Level III Orbiter Program Office has initiated a Product Quality Improvement Council at Rockwell, which includes Rockwell and their subcontractors. It is "results" oriented and provides meritorious citations where quality and usability have remained at a high level or have shown improvement. The results of these efforts show an overall reduction in the number of nonconformance reports. Rockwell has initiated several personnel and hardware programs to enhance product quality such as their Product Quality Assessment Team that examines the hardware at the subcontractors, and their Employee Motivation Program that rewards plant personnel based upon peer nominations. In addition, all quality plans are approved by the President of the Orbiter Division. Production/productivity quality reviews are held quarterly, thereby providing for lower level information to reach top management.

Other NSTS contractors, i.e., Martin, Thiokol, and Rocketdyne, have similar programs. The key to the overall program has been to involve senior management as well as all disciplines concerned. Rather than provide the Panel with numerous details, I recommend that you include such a discussion item on your agenda when you visit those organizations.

With specific regard to operational suitability, the NSTS program has an on-going hardware enhancement effort the goal of which is to optimize, insofar as possible, KSC's turnaround process. To meet that goal, the Orbiter Project Office continues to process appropriate ground and flight equipment changes to achieve a turnaround time of 35 workdays by the end of September, 1984, which should support our STS flight manifest through FY'86. To provide you an understanding of the extent of our efforts, the following is a partial list of candidate enhancements for study: thermal protection system; deletion of the ammonia boiler system; heater blanket test receptacles; opening the payload bay door without Orbiter power; solid polymer electrolytic fuel cells; OMS/RCS simplification for removal, installation, and test; restriction of connector retest to critical circuits only; Orbiter brakes modification; and upgrading the main engines to reduce maintenance and inspection. Some changes that have already been approved up through the Orbiter level include: Orbital Maneuvering System pod commonality, Aft Reaction Control System tanks commonality, wiring for cargo battery charging, component heater blankets, and moving the desiccator from behind the storage locker.

2. Space Shuttle Main Engine (SSME)

ASAP Recommendation:

The SSME program should proceed with full NASA support and resources to firm up the content and planning for SSME improvement and to implement the program and pursue the objectives vigorously. Retrofit of certified improvements during scheduled or unscheduled removals of the engines is firmly recommended. The plans should continue to include the activity on a full redesign of the high pressure turbomachines that was begun this year. The Aerospace Safety Advisory Panel believes this effort to be necessary to achieve the margin of safety required for routine operations and long life of the engines. As testing to demonstrate margin for operation at the 109%

level will involve operation at thrust levels higher than 109%, there will be temptation to increase the Shuttle performance by utilizing higher thrust. The ASAP advises strongly against such a decision. Operational reliability, and the concomitant safety can be achieved only by operating the engines at thrust levels below the maximum demonstrated in a few tests to show that a margin exists.

NASA Response:

NASA management is fully supportive of SSME improvements. We are committed to the Phase II modifications of the high pressure lox and fuel turbopumps and have presently allocated $75.7M in FY'84 and $55.5M in FY'85 for design, development, and testing to be performed by the engine contractor. As part of the Phase III program, a complete redesign of the lox high pressure pump is underway.

It is the intent of NASA to preserve the margin that is being designed into the Phase III configuration engine for reliability purposes. At this time, we have no plans to conduct flight operations above the 109% thrust throttle settings. We are currently assessing various configuration options for the Phase III engine. We will assess any limitations individually to determine if design action should be undertaken in Phase III to eliminate the restriction.

3. Landing Gear

ASAP Recommendation:

A complete structural and mechanical suitability review of the Shuttle landing gear be made by an engineering organization with commercial transport experience for the purpose of suggesting alternative landing gear configurations and setting target margins for structures and the wheels, brakes, and axles. This review should include but not be limited to:

a. The practicality of converting to a four-wheel main gear truck within the present wheel well.

b. The practicality of putting an extended or extendable strut on the nose gear for the purpose of changing the Orbiter ground attitude (more positive angle of attack), thus relieving the main gear roll-out loads.

c. The feasibility of increasing brake capacity by a major percentage (at least 25%).

d. A thorough review of the weak points on the present gear followed by suggestions for beef-up to bring the margins into partial comparability with the margins of modern transport aircraft in the landing mode.

NASA Response:

In consonance with part of the ASAP recommendation, the Orbiter brake design and operational experience has now been reviewed by an expert committee which included representatives having commercial transport experience. The committee's findings and recommendations were reviewed with the Panel on April 26, 1984, at JSC. The conclusions reached by the committee's board were: (1) no flight safety issue exists with the current design; (2) a number of notable Orbiter brake design characteristics are different from current industry design practices; (3) the cause of brake damage has not been conclusively determined by analysis and confirmed by ground tests, and there is insufficient flight data; and (4) The potential contributors to damage are related to dynamics, hydraulics, mechanical vibration, and chatter.

The committee's board recommendations and status are listed below:

(1) Addition of flight instrumentation. This has been approved for implementation and is being installed on Challenger for its next flight. The redundant instrumentation being used should be sufficient to characterize the brakes' dynamic performance characteristics under actual flight conditions.

(2) Provision for hydraulic system damping. This is now in work at Crane Hydroaire for evaluation to determine the proper orifice sizing.

(3) Modifications of the brake hardware. The 360° saddle has been installed on the two outboard wheels for STS 41-D. Clips for the beryllium drive lugs are being redesigned and will be available for STS-41G. The wheel lug/spline covers are being redesigned for deeper contact between the wheel and brake and will be available for 41G.

(4) Modifications to the crew pedal. This is a simple change which will be accomplished after the crew input on their requirements.

(5) Testing of the carbon liner material. These tests have been conducted to characterize carbon liner material as input data for the math model of the brake system.

(6) Provide measurements of vehicle structure. This has been approved to provide data for the math model.

(7) Develop a math model. This is being accomplished both at JSC and Rockwell. It is expected to be completed in about 6 months.

(8) Perform dynamometer testing at Wright Patterson. Dynamometer testing is being performed at Goodrich.

The four ASAP recommendations have been studied, and the following conclusions were reached:

a. The 4-wheel truck would require a major gear design change and extensive modification to the Orbiter wings to increase the landing gear compartment size. This change would be very expensive, and the vehicle would have to be used as a test bed.

b. The longer nose gear would reduce the tire loads imposed on the main landing gear and improve the single tire rollout capability. However, the tires, along with the wheels and bearings, have been shown to provide adequate margins. Although the longer gear design is possible, it is not simple and would introduce additional failure modes if it were to be fitted within existing structural interfaces. It would cost about $50M and take about three years to develop. However, with recognition to the ASAP point, we are still giving redesign (extension) consideration to provide the optimal load relief for the minimal program impact.

c. It is feasible to increase the brake capacity by 14 percent using the existing wheel. The payoff would not be significant that is, an increase of only several knots in the landing speed would result. The present design will stop the vehicle in about 2500 feet after application of brakes. That additional 14 percent capacity would shorten the landing distance by about 100 feet. Greater increases in brake capacity could be accomplished using structural carbon but would require redesign of the wheel system. The present beryllium carbon brakes are already designed to cover abort landings up to the maximum (240,000 pounds) landing weight allowed. The greatest braking capacity is required during emergency braking which imposes an energy level of 55 million foot-pounds per brake or 220 million foot-pounds for the entire vehicle. The emergency capability of 55 million foot-pounds per wheel has been demonstrated during dynamometer tests at Goodrich. The energy used for the first 10 Shuttle flights has varied from 26.7 to 142.2 million foot pounds per vehicle so a substantial margin exists. A maximum pressure braking test for a short duration of time was conducted on STS 6, the result being the shortest rollout distance achieved

(7180 feet). Clearly we are not pleased that brake damages are being experienced and that operational restrictions are placed upon the crew. However, as mentioned earlier, these are not considered safety critical failures, and steps are being taken to understand and fix the brakes by the addition of flight instrumentation, conduct of additional dynamometer tests, and development of comprehensive dynamic math models. It is quite apparent that there will be some time before the data can be gathered, analyzed, and the corrected. It should be noted that the Orbiter, without the ability to taxi, is unique from aircraft, and correcting this problem will require more patience than with aircraft. With this approach, however, we will have obtained the best possible data, ie., from the flight itself rather than by analysis or simulations.

The ASAP mentioned other concerns in the text regarding the brakes. One of these was the 75 pound force to achieve the maximum 1500 psi brake pressure. The pedal force has been designed to MIL-B-8584C and is consistent with commercial transports. There is activity presently underway to to lighten the pedal force loads.

While it is true that the Orbiter has been designed with less margin of safety than commercial transports, another ASAP concern, it should be observed that the condition for which the design is based is a fully loaded landing weight which is more stringent than the aborted take-off requirements for commercial aircraft. Actually, the fuselage is the load limiting component of the vehicle, not the landing gear.

d. The landing gear has been reviewed numerous times during JSC conducted structure reviews and has adequate margins of safety for all expected flight conditions. It is the program's understanding that the ASAP members present during the April presentation were satisfied with the adequacy of the landing gear.

4. Logistics and Maintenance

ASAP Recommendation a:

A single authority should be established and responsible for all logistic systems.

NASA Response:

The Office of Space Transportation issued on May 1, 1984, the "National Space Transportation System, Space Shuttle Integrated Logistics Support Policy" (SFO PD-110.5.). That document assigns overall responsibility for policy guidance, resource allocation, and management oversight to the Director of Space Shuttle Operations. Level II is responsible for the management of the integrated logistics support and is charged with implementation of the policy. Space Shuttle Program Directive No. 58A, dated March 25, 1983, was prepared to formally establish the NASA/DOD Space Shuttle Integrated Logistics Panel (ILP). They have been meeting on approximately a quarterly basis. The NASA DOD Integrated Logistics Panel (ILP), co-chaired by JSC and USAF Space Division, represents the top authority over combined NASA/USAF logistics programs and policies. JSC, KSC, and MSFC have a centralized Space Shuttle Logistics Manager who is the top authority over Space Shuttle Logistics for that center. Each center's logistics manager is also a member of the ILP and presents center problems and areas of concern to the ILP for resolution. Besides being the ILP co-chairman, the JSC representative is responsible for implementing Space Shuttle policies throughout the Shuttle program.

The logistics policy document has been prepared consistent with the plan to transfer to KSC the various element logistics management functions commencing with the ET and SRM by January 1985 and the Orbiter and SSME by January 1988. These are targeted as the latest dates, and hopefully they can be moved forward.

ASAP Recommendation b:

An overall maintenance plan should be established attempting to provide for at least the next decade.

NASA Response:

A long-term overall maintenance plan is being developed by Level II for the Shuttle system. This plan will become a part of the STS Integrated Operational Launch Site Support Plan to be developed by January 1985.

The "Space Shuttle Integrated Logistics Support Policy" provides a statement in Section 8 relating to the program's maintenance and repair policy. Considerable activity is now being devoted by Level II to updating the Shuttle Maintenance Baseline document (JSC 08151). A Level II change request is scheduled for action in early July and, when approved, will formally control all maintenance sources in accordance with paragraph 8.5 of the policy. The plan is to prepare an "Intermediate and Depot Maintenance Requirements System" (IDMS) relating to maintenance as "Operations and Maintenance Requirement Specification Documents" (OMRSD's) relate to vehicle processing. The objective is to be able to repair any device at KSC in the event that a vendor goes out of business.

ASAP Recommendation c:

The role of the Shuttle Processing Contractor (SPC) in the vital sphere of logistics should be clearly defined as soon as possible.

NASA Response:

A clear and detailed definition of the SPC Logistics roles and responsibilities is available in the Lockheed Space Operations Company's (LSOC) DRL 040 Logistics Support Plan, dated January 10, 1984. A copy has been transmitted to Mr. Roth, ASAP Staff Director, for the Panel's use. Key logistics support objectives are to:

(1) Develop plans for long-term support from off-site maintenance facilities.

(2) Establish a responsive and reliable transportation pipeline to assure timely and damage free movement of SPC material.

(3) Review subcontractor and vendor support for element hardware to ensure that the most economical sources are being used.

(4) Maintain accountability and control of all SPC spares and equipment.

(5) Develop an approach with NASA/KSC/JSC/MSFC to minimize the risk associated with out-of-production flight hardware and associated support equipment.

(6) Provide a logistics support system that uses a common data base for provisioning and reporting that is visible to users at KSC and Vandenberg Launch Site.

(7) Establish provisioning models that will ensure an adequate depth of spare and repair parts to efficiently and economically support the mission model.

(8) Provide a method of tracking repairables in the repair cycle to encourage a timely maintenance repair program that is responsive to need dates and that provides maintenance data for adjustment of range and depth of spare/repair part inventory, adjustment of maintenance activities, and collection/control of maintenance costs.

(9) Develop a logistics launch readiness review system that has a milestone for each mission.

(10) Acquire that logistics operation and maintenance documentation required to accomplish provisioning of spares, overhaul, and repair planning.

ASAP Recommendation d:

Spacelab, Shuttle/Centaur, Inertial Upper Stage, and Payload Assist Module should be included in the logistics plans.

NASA Response:

Although a great deal of progress has been made in support of the Space Shuttle Logistics Elements, additional work needs to be completed before the Space Shuttle carriers are formally integrated into NASA/DOD logistics plans. The decision not to include Spacelab, Inertial Upper Stage, and Payload Assist Module (PAM) in the Integrated Logistics Panel (ILP) charter was briefed to the NSTS Steering Group co-chairman in the NASA/DOD Logistics briefing on January 11, 1984. Both co-chairmen (NASA/DOD) concurred with the "Space Shuttle only" concept of the ILP charter. Under the present concept of the STS operations, incorporation of the carriers into logistics will not be considered until the STS elements have been adequately accommodated. They are, of course, candidates for inclusion at some future date. However, at the present time, logistics, including purchase of spares, is being handled by the sponsoring organizations: Lewis Research Center, the Air Force, and McDonnell Douglas. Since PAM is a commercial venture, it probably will not become a part of the Shuttle logistics system. The uniqueness of the ESA developed and funded Spacelab required a program which was independent of the Shuttle during the R&D phase. The Europeans have funded some spares and maintenance activities which have been supplemented by NASA funding where considered inadequate. As the R&D phase concludes, NASA will gradually phase Spacelab into the Shuttle Integrated Logistics Program, and it is anticipated that KSC will assume full responsibility for their logistics. No date has been established however for completion of the turnover to KSC.

5. Orbiter Structural Loads

ASAP Recommendation:

The Aerospace Safety Advisory Panel recommends that the National Aeronautics and Space Administration expedite the derivation of a new set of loads based on the latest wind tunnel and flight data. The Aerospace Safety Advisory Panel further recommends that renewed efforts be made to validate the final derived structural loads with full-scale flight data.

NASA Response:

We concur with the Panel's recommendation. A new loads cycle (6.0) was initiated in October 1983 and is scheduled to be completed by 1987. This loads cycle will update the Orbiter work to include the latest wind tunnel and flight data to certify the Orbiter for full operational capability. The final derived structural loads will be validated with the full scale flight data.

The OFT (Orbital Flight Test) Program results indicated higher than anticipated loads on the Orbiter wing during ascent, and higher than expected thermal stress during entry. In 1982 JSC initiated the OCA (Orbiter Capability Assessment) to address these issues on a priority basis and to provide interim flight clearance of the structure until a new load/stress cycle could be completed.

Current flights of the Orbiter are supported by the results of OCA, with the exception of the wing. OCA results regarding the wing did not satisfactorily match flight test results. In some cases the differences were significant. Therefore, each Orbiter in the flight inventory is having strain gages installed in the wings to monitor flight load levels, and an additional analytical task has been initiated to obtain a better correlation between aero and structural loads and to conduct wing modifications. The current plan to resolve the wing problem consists of the investigation of near-term structural modifications to achieve flight conditions required at the Western Test Range and the evaluation of aerofixes, such as a spoiler, to achieve flight conditions required in the 1989 timeframe.

6. Orbiter Landing Speed and Pitch Control

ASAP Recommendation:

NASA Headquarters should request Langley Research Center (LaRC) to review the "state of the art" in canard configured aircraft, and prepare briefings to the Aerospace Safety Advisory Panel and NASA Headquarters on the advantages and limitations of canard configurations as applied to the Orbiter. In parallel, Johnson Space Center (JSC) should be asked to explore the practical problems of installing controllable canards on the Orbiters for use in landing.

NASA Response:

In accordance with the ASAP request, Langley Research Center has reviewed the use of canards. They will brief the ASAP and NASA Headquarters in the near future.

JSC has explored the practical problems associated with installing canards on the Orbiter and presented its conclusions to the Panel. During the presentation, a brief background was given, which provided a description of the present Orbiter landing characteristics and a discussion of possible canard benefits. Canard studies in the early design phases of the Orbiter and current Orbiter canard studies were summarized. The practical problems were detailed which showed that to install canards, the program would be required to commit to: redesign of a number of on-board systems, structural redesign of the forward fuselage, re-creation of wind tunnel data bases, and Orbiter reverification. Significant Orbiter down-time and schedule impacts would also result. In summary, the impact of adding canards to the present design are considered prohibitive compared to the benefits. Future generation vehicles will include consideration of canards.

7. Shuttle Processing Contractor (SPC)

ASAP Recommendation:

National Aeronautics and Space Administration should clarify as rapidly as possible its internal organizational arrangements that will support routine operation of the Space Transportation System. Such organizational clarity will be a major factor in achieving the objectives noted above and in assisting the SPC.

NASA Response:

KSC has been reorganized to provide a single, principal interface with the SPC. Previously KSC had three divisions with launch operations responsibilities which have now been combined under one director (Shuttle Management and Operations) reporting to the KSC Center Director. This was accomplished prior to the SPC contract award in order to unify the management of those functions. More recently, the Director of the Shuttle Management and Operations Directorate has been assigned the task of Contract Manager of the SPC to insure close coordination of SPC and civil service personnel for launch operations.

The SPC is now on-board. Although they have been highly successful in hiring personnel who have prior Shuttle experience, the level is not of a degree that precludes NASA involvement. New organizational techniques are used by this contractor, but the management is operating in a takeover mode. What this means is that Lockheed had planned and proposed to provide a service to NASA that had been organized strictly for operations, not taking into account the realities that some integration tasks are still being implemented as we move toward an operational vehicle. The Lockheed proposal presupposed that a logistics program is in place and that no launch vehicle modifications would be necessary. Thus, a straightforward standardized mode of operation was assumed. This, of course, did not permit sufficient leeway for accomplishment of vehicle improvements, and NASA involvement at this time has necessarily become greater than what SPC had anticipated before the award of the SPC contract. After vehicle change activity is reduced, KSC will be in a position to proceed with full operational utility. However, this delay could be to our advantage since we need to carefully deliberate all changes to a successful system.

Lockheed had proposed to implement a large number of innovative changes or techniques for the Shuttle to become operational. These efforts are organized into major program tasks in the areas of management, operations, process planning and control, management systems, process/support operations, work stations, and Vandenberg Launch Site Unique Operations. A description and scheduling of these tasks may be obtained from the KSC document entitled "Description of Evolution Tasks, Initial Baseline," dated March 22, 1984. (The ASAP Staff Director has been given a copy for Panel use). The effort is too extensive to discuss here, and I would invite the Panel to visit KSC to review this subject in depth. Plans and schedules could be addressed at that time. What is significant is that an evolution plan exists and is receiving high level attention. The Director of Shuttle Management and Operations conducts a half-day meeting twice a week on the total program evolution. This management pace is expected to continue into August to assure a sound transition to operations.

In your report's conclusions, the Panel refers to implementation of a unified logistics system and acquiring adequate spares. These are discussed in Recommendation No. 4. The relationship between the Vandenberg Air Force Base and the KSC for Shuttle operations is being worked between the KSC Director of Shuttle Management and Operations and Lt. Gen. McCartney, Commander of Space Division. The Air Force and NASA have agreed upon a policy for the engineering role in which a NASA/AF team directs the contractor. Mr. W. Murphy, formerly of KSC and now detailed to Vandenberg, heads that effort. In that role, NASA reports to the Air Force (Col. Boland). Second level directors are all NASA personnel. The staffing is complete, and personnel are in residence there now. The NASA operations role has not been determined at this time. Lockheed is proposing on a delta effort which would maintain resident force for the facility and would provide travel for the KSC launch team for the small number of Shuttle launches at VAFB. This approach represents our current thinking and should not be construed as the final program plan.

8. Safety of Flight Operations

ASAP Recommendation:

A "Director" or "Chief" of Flight Operations should be identified and should be the focal point of flight safety matters in NASA Headquarters.

This "Director" should serve as a channel of communication from the branch flight operations level at the Centers to whatever administrative level that is necessary to fully resolve a flight safety problem.

National Aeronautics and Space Administration Headquarters, through the "Chief of Flight Operations" and the Intercenter Aircraft Operations Panel, should complement the supervision of flight operations with studies and educational programs aimed at the human factor problem in aviation accidents and assure that appropriate policy documents are issued by Headquarters to meet operational safety needs.

NASA Response:

We have recently brought Mr. Gary Krier to Headquarters to serve as Director of the Aircraft Management Office. His responsibilities comprise overall aircraft operations and management. He is expected to provide the key channel of communication to fully resolve flight operations problems.

The Chief Engineer's Office has been deeply involved in aviation safety oversight roles. That office is directly supporting two major aircraft research programs underway in OAST: the Rotor System Research Aircraft X-Wing Program and the Controlled Impact Demonstration Program. Biennial aircraft operations reviews are conducted at all centers in conjunction with the Intercenter Aircraft Operations Panel (IAOP). At the request of the IAOP, training to the panel in the area of systems safety concepts and procedures was provided. This office is contributing a heightened safety awareness to the centers in providing: guidance on aircraft fire extinguishers, aircraft accident checklists, accident investigation kits, and video tapes, in addition to nearly daily requests on a variety of other safety subjects. Further, the oversight role is enhanced through liaison with other agencies and services, as exemplified by the recent Memorandum of Agreements with the USAF and the Army, to exchange mishap data on aircraft of mutual interest.

At my request, flight operations reviews were conducted by Ecosystems International, Inc. to assess the level of aviation flight safety activities at the Langley Research Center in September of 1982, Johnson Space Center in November of 1982 and

Ames Research Center and its Dryden Flight Facility in December of 1983. The review team found that all the activities reviewed were performing in a highly professional and competent manner.

The other ASAP point was the need to complement the supervision of flight operations with studies and educational programs aimed at the involvement of human factors in accidents. It is becoming increasingly evident that both the physical aspects of the cabin lay-out and the mental make-up of its occupants comprise the total realm of human factors. Over the years, the Agency, as well as others in the aircraft industry, has recognized the importance of the physical part, that is, the placement of switches and controls, the ease and readability of instruments, and other such physical parameters. However, the psychological make-up of personnel has not been as readily acknowledged as an independent contributor, and therefore little is known about it. Research is being conducted by both the FAA and the USAF. NASA monitors the efforts in this field and maintains cognizance of results to date. However, we are unaware of courses on this subject that would be effective in avoiding the type of accidents in which the crew's psychological make-up plays a key role.

We have made progress on two other areas which the Panel addressed in the Annual Report: enhancement of effective communication and upgrading policies and management instructions. I would like to address these two subjects as well.

In facing up to communication inadequacies, I believe that the Agency has now taken significant steps to enhance effective communication on aviation safety and related matters, both up and down the management chain from Headquarters to the flight operations at the centers, as well as laterally at the center level. For one thing, we have increased the frequency with which the IAOP meets to discuss safety issues. This panel met at the USAF Safety Center in December, at JSC in March, and at KSC in June, a fourfold increase over previous history. For another, the IAOP is now sponsoring a newsletter that will publicize on a quarterly basis significant aviation activity.

The Center Aviation Safety Officers (ASO), at a recent ASO meeting conducted at Ft. Rucker, Alabama, praised the significant improvements in intercenter communications. NASA was pleased that one of the ASAP members, Lieutenant General Davis, was able to participate in this meeting and welcomed his participation and inputs.

We have taken measures to insure that communications are supported by appropriate actions to produce more effective implementation of safety. To this end, more emphasis is being placed on operations reviews which include safety. So far, reviews since December 1983 include Dryden, KSC, Wallops and

Lewis. Three other reviews are scheduled this year: Langley, Johnson, and Marshall.

We are in the process of updating the Headquarters aircraft and flight operations policies and management instructions. The status and schedule of each is presented below.

Number	Title	Schedule
NMI 1152.47B	Intercenter Aircraft Panel	Published
NMI 7920.1A	Administrative Aircraft	August 1984
NMI 7910.1B	NASA Aircraft Management	Signed
NMI 7910.2	Airworthiness	Published
NHB 7920.x	Administrative Aircraft Operations Manual	Fall 1984

In addition, we already have updated revisions of the following documents.

NMI 1102.2C	Roles and Responsibilities for the Associate Administrator for Space Technology
NMI 1103.D	Roles and Responsibilities for the Chief Engineer
NMI 1103.C	Roles and Responsibilities for the Associate Administrator for Management Operations
NMI 7900.1B	Delegation of Authority to Approve Policies and Other Matters Related to NASA Aircraft

APPENDIX 3

esa
european space agency
agence spatiale européenne

CAB/INT/I.31/KB/MTL/5504

Paris,

Dear Mr Nelson,

I refer to the transcript of the testimony I gave to your Sub-committee on 7 March 1985, and in particular, to your question on Ariane launch fee.

The answer I gave (line 593) is correctly stated. However, to reflect fully the idea I wished to express, my answer should have read:

> "The Member States of ESA pay a slightly higher launch fee against the recognition of launch priority and guaranteed costs over a certain period."

I would appreciate it if the above was included in the hearing record.

Yours sincerely,

R. Lüst
Director General

The Honourable Bill Nelson
Chairman
Sub-committee on Space Science
and Applications
U.S. House of Representatives

Washington, D.C. 205158

APPENDIX 4

ARTUR MAGER, PH.D.
CONSULTANT
1353 WOODRUFF AVENUE
LOS ANGELES, CALIFORNIA 90024

(213) 474-6448

March 26, 1985.

The Honorable Don Fuqua, Chairman
Committee on Science and Technology
2321 Rayburn House Office Building
Washington, DC 20515

Attention: Subcommittee on Space Science and Applications.

Dear Mr. Chairman:

As a witness before the Subcommittee on Space Science and Applications on February 26, 1985, I have edited and am returning the hearing transcript forwarded to me for review. I request that the following information be included in the hearing record:

Page	Line(s)	Proposed wording.
76	1770	...the Spot system that the French are...
77	1777-80	...and if there is not going to be research in that area at NASA, under the proposed commercialization arrangement, Landsat would very rapidly become obsolete.
77	1795-99	...research on things like the multilinear array, for example. The commercial remote sensing system which we will put up will become obsolete in no time, and our foreign...
82	1919-20	...doubling of $27 million is relatively not a very large...

I understand that this letter may be inserted in the transcript in the form of an appendix and referred to by footnote in the main text.

Sincerely,

Artur Mager

Artur Mager

APPENDIX 5

Carnegie-Mellon University

Office of the Dean
Mellon College of Science
Schenley Park
Pittsburgh, Pennsylvania 15213
[412] 578-2484

March 11, 1985

Mr. Radford Byerly, Jr.
Science Consultant
Committee on Science and Technology
2321 Rayburn Building
Washington, D. C. 20515

Dear Mr. Byerly:

Enclosed are the two documents from which I quoted during my testimony on February 26th and which you asked me to provide with reference to the official record. I was glad to have the opportunity to appear and clarify the question raised.

Please feel free to telephone me if you have additional questions.

Sincerely yours,

Robert F. Sekerka
Dean, Mellon College of Science

Enclosures

Revised Draft of Congressional Testimony— R. F. Sekerka, 2/15/85

Microgravity Science and Applications

Most of the members of the SAAC Subcommittee on Microgravity Science and Applications have been thoroughly familiar with NASA's microgravity program for over a decade; some have had experience as principal investigators in NASA's microgravity program and others have served on advisory committees of NASA, the National Research Council (NRC) or the the Universities Space Research Association (USRA). For instance, Dean Robert Sekerka participated in the STAMPS (Scientific and Technological Aspects of Materials Processing in Space) study, conducted under the auspices of the NRC during the mid 1970s, which was instrumental in NASA's reformulation of its materials processing program to include the fundamental, ground—based research that is necessary to perform meaningful experiments in materials science and processes in the microgravity environment of space.

The Subcommittee is enthusiastic about the broad range of promising research results that has been forthcoming in such areas as metals and alloys, glasses and ceramics, biotechnology, electronic materials, combustion science, fluid dynamics and transport phenomena, and fundamental areas of chemistry and physics such as critical phenomena. It is also pleased with the program management provided by Mr. Richard Halpern, particularly the reestablishment of discipline working groups, the design of flight equipment tailored to specific experiments, and sound analysis of fiscal aspects of the program. The Subcommittee also applauds the involvement of industry at various levels—e.g., via Joint Endeavor Agreements (JEA's) with McDonnell—Douglas Aerospace Corporation, Microgravity Research Associates, and the 3M Corporation; Technical Exchange Agreements (TEA's) with about six others; and joint initiatives with about a dozen others.

So it can be said that the ground—based part of the research program is moving along rather well and we are beginning to get some experience under actual microgravity conditions; however, the total amount of experiment time under microgravity conditions is still minuscule when compared to the usual experience base in materials research needed to obtain reliable, reproducible results. Since gravity is a relatively weak force when compared, for example, to the electromagnetic forces that take part in chemical reactions, its effects are manifest only when other forces are held in abeyance; it then sometimes emerges as a decisive factor. Therefore, careful and painstaking experiments are needed to isolate the role of gravity in scientific phenomena and practical processes (or the improvements directly attributable to its relative absence), thereby permitting the exploitation of the microgravity environment of space for valuable scientific knowledge or even possibly for profitable space—based manufacturing.

The proposed Space Station, on the horizon for the early 1990's, is expected to provide extended time under microgravity conditions with continuous interaction by man in a research mode similar to that on earth; this should provide, for the first time, the opportunity for proof of concept of the potential opportunities that our limited microgravity experience base up to now has suggested. In order to take advantage of this opportunity, however, we must accelerate our research efforts significantly over the intervening five years. This is crucial if we are to make realities of such opportunities as biomedical processing and crystal growth that were mentioned by President Reagan in his State of the Union Address.

The most important opportunities for significant time under microgravity conditions during the next five years will be aboard the Space Shuttle. Unfortunately flight time for microgravity experiments has been severely limited by both inadequate program budgets and Shuttle manifesting priorities. If this continues, the Space Station will soon be upon us, our microgravity experience base will still be meagre, and we will have to settle for flying relatively obsolete flight hardware aboard the Station.

Although some budgetary increase for this program within the Office of Space Science and Applications (OSSA) is planned—and we are grateful for this increase in view of budget cuts in many other areas—it is extremely important to recognize that the Microgravity Science and Applications Program is still in its infancy relative to other applications programs such as communications and remote sensing; it currently constitutes only about 2% of the total OSSA budget and has a program staff that is much too small to meet current demands. Therefore, in order to meet the window of opportunity afforded by the Space Station, it will be necessary to program a more significant schedule of increases—perhaps doublings—until a stable, more mature program is established.

Microgravity Science
and Applications Division
NASA, Headquarters

Presentation to:
Senate Staff

January 23, 1985

Richard E. Halpern
Washington, D.C.

MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

MAJOR ISSUES AND CONCERNS

- LACK OF FLIGHT OPPORTUNITIES
  - STS MANIFEST CHANGES
  - NO DATA AND ADDITIONAL COSTS
- LACK OF FUNDING FOR NEW INITIATIVES
  - GROUND-BASED RESEARCH NEEDED SOON FOR SPACE STATION ACTIVITIES
  - SECOND GENERATION HARDWARE LEADING TO SPACE STATION
- LACK OF ADEQUATE PERSONNEL FOR PRESENT PROGRAM
  - INCREASE IN RESPONSIBILITIES FOR COMMERCIAL AND SPACE STATION TASKS

FLIGHT EXPERIMENT PROGRAM THRU CY 1986

		PLANNED LAUNCH DATE		
	*8/83	ACTUAL	5/84	PROJECTED 11/84
O SPACELAB 1 (SL-1)				
- EUROPEAN MATERIALS SCIENCE AND TECHNOLOGY	10/83	11/83		
O 36 EUROPEAN SCIENTIFIC EXPERIMENTS				
O 1 U.S. TECHNOLOGY EXPERIMENT (TRIBOLOGICAL)				
O ACOUSTIC CONTAINERLESS EXPERIMENT SYSTEM 1 (ACES-1)	1/84	2/84		
- STUDY A LEVITATED FLUORIDE GLASS SAMPLE				
O ISOELECTRIC FOCUSING EXPERIMENT 1 (IEF-1)	1/84	2/84		
- TEST EFFECTS OF ELECTRO-OSMOSIS ON SEPARATION OF BIOLOGICAL COMPOUNDS				
O MONODISPERSE LATEX REACTOR (MLR)	1/84	2/84		
- PRODUCE LARGE DIAMETER LATEX SPHERES				
O CONTINUOUS FLOW ELECTROPHORESIS SYSTEM (CFES)	5/84	8/84	8/84	
- MDAC PAYLOAD				
O AUTOMATED DIRECTIONAL SOLIDIFICATION FURNACE 1 (ADSF-1)	5/84		8/84	5/85
- EUTECTIC GROWTH OF MANGANESE BISMUTH				
O MATERIALS SCIENCE LABORATORY 1 (MSL-1)	5/84		11/84	10/85
- LIQUID PHASE MISCIBILITY GAP MATERIALS				
- VAPOR GROWTH OF ALLOY TYPE SEMICONDUCTOR CRYSTALS				
- CONTAINERLESS PROCESSING OF GLASS FORMING MELTS				
- DIFFUSION COEFFICIENT OF LEAD ZINC				
- DIRECTIONAL SOLIDIFICATION OF LEAD TIN TELLURIDE				
O ISOELECTRIC FOCUSING EXPERIMENT 2 (IEF-2)	8/84		8/84	5/85
- ISOELECTRIC FOCUSING PHENOMENA				
O CONTINUOUS FLOW ELECTROPHORESIS SYSTEM (CFES)	8/84		11/84	3/85
- MDAC PAYLOAD				

* NO MIDDECKS SCHEDULED BEYOND FEBRUARY 1985 IN STS AUGUST 1983 MANIFEST

FLIGHT EXPERIMENT PROGRAM THRU CY 1986

	LAUNCH DATE	
	5/84	PROJECTED 11/84
O DIFFUSIVE MIXING OF ORGANIC SOLUTIONS 1 (DMOS-1) - 3M PAYLOAD		11/84

FLIGHT EXPERIMENT PROGRAM THRU CY 1986

	PLANNED LAUNCH DATE			
				***PROJECTED
	8/83	ACTUAL	**5/84	11/84
O AGGREGRATION OF RED BLOOD CELLS 1 (ARC-1)	8/84		11/84	1/85
- AUSTRALIAN EXPERIMENT				
O MATERIALS SCIENCE LABORATORY 2 (MSL-2)	10/84		8/85	8/85
- SOLIDIFICATION OF COBALT SAMARIUM				
- UNDERCOOLING OF NICKEL TIN				
- TWO PHASE DROP BEHAVIOR				
O SPACELAB 3 (SL-3)	11/84		1/85	4/85
- SOLUTION GROWTH OF CRYSTALS IN ZERO GRAVITY				
- MERCURIC IODIDE CRYSTAL GROWTH				
- DYNAMICS OF ROTATING AND OSCILLATING FREE DROPS				
O PROJECTED FOR CY 85				
- AUTOMATED DIRECTIONAL SOLIDIFICATION FURNACE 2 (ADSF-2)	2/85		3/85	
- SPACELAB D-1 (SL-D1)	6/85		10/85	10/85
O FLY MSL-1 EXPERIMENTS AS PART OF GERMAN MISSION				
- ELECTROPHORESIS OPERATIONS IN SPACE 1 (EOS-1)	7/85		7/85	11/85
O MDAC PAYLOAD				
- MATERIALS SCIENCE LABORATORY 3 (MSL-3)	11/85		11/85	12/85
O SOLIDIFICATION OF COBALT SAMARIUM				
O UNDERCOOLING OF NICKEL TIN				
O TWO PHASE DROP BEHAVIOR				

** NO MIDDECKS SCHEDULED BEYOND JULY 1985 IN STS MAY 1984 MANIFEST

*** NO MIDDECKS SCHEDULED BEYOND MAY 1985 IN STS PROJECTED NOVEMBER 1984 MANIFEST

FLIGHT EXPERIMENT PROGRAM THRU CY 1986

		PLANNED LAUNCH DATE		
	8/83	ACTUAL	5/84	PROJECTED 11/84
PROJECTED FOR CY 1986				
O ELECTROPHORESIS OPERATIONS IN SPACE 2 (EOS-2)	1/86		7/86	6/86
O MATERIALS SCIENCE LABORATORY 4 (MSL-4)	7/86		7/86	7/86
O MATERIALS SCIENCE LABORATORY 5 (MSL-5)			10/86	10/86
O MONODISPERSE LATEX REACTOR 6 (MLR-6)			8/84	5/85
- PRODUCE LATEX SPHERES GREATER THAN 30 MICROMETERS				
O MONODISPERSE LATEX REACTOR 7 (MLR-7)			2/85	
- PRODUCE LATEX SPHERES 50 MICROMETERS OR LARGER				
O ACOUSTIC CONTAINERLESS EXPERIMENT SYSTEM 2 (ACES-2)			3/85	
O MONODISPERSE LATEX REACTOR 8 (MLR-8)			5/85	
- PRODUCE 100 MICROMETER DIAMETER LATEX SPHERES				
O AGGREGATION OF RED BLOOD CELLS 2 (ARC-2)			7/85	
- AUSTRALIAN EXPERIMENT				

SPACELAB AND CARGO BAY EXPERIMENTS

MEA-1 (JUNE 1983)
- 3 INVESTIGATIONS SELECTED 1977

SPACELAB III (APRIL 1985)
- 2 INVESTIGATIONS SELECTED 1977

MSL-2 (AUGUST 1985)
- 2 INVESTIGATIONS SELECTED 1977
- 1 INVESTIGATION SELECTED 1983

MSL-1 (OCTOBER 1985)
- 4 INVESTIGATIONS SELECTED 1977
- 1 EXTENSION OF ROCKET EXPERIMENT SELECTED 1976

MSL-3 (DECEMBER 1985)
- 2 INVESTIGATIONS SELECTED 1977
- 1 INVESTIGATION SELECTED 1983

MSL-4 (JULY 1986)
- 2 INVESTIGATIONS SELECTED 1977
- 1 EXTENSION OF ROCKET EXPERIMENT SELECTED 1976
- 1 INVESTIGATION SELECTED 1984

MSL-5 (OCTOBER 1986)
- 1 EXTENSION OF EXPERIMENT SELECTED 1976
- 2 INVESTIGATIONS SELECTED 1977
- 1 INVESTIGATION SELECTED 1983
- 1 NEW SLOT

MSL-6 (JANUARY 1987)
- 1 INVESTIGATION SELECTED 1977
- 1 EXTENSION OF ROCKET EXPERIMENT SELECTED 1976
- 1 INVESTIGATION SELECTED 1984
- 1 NEW SLOT

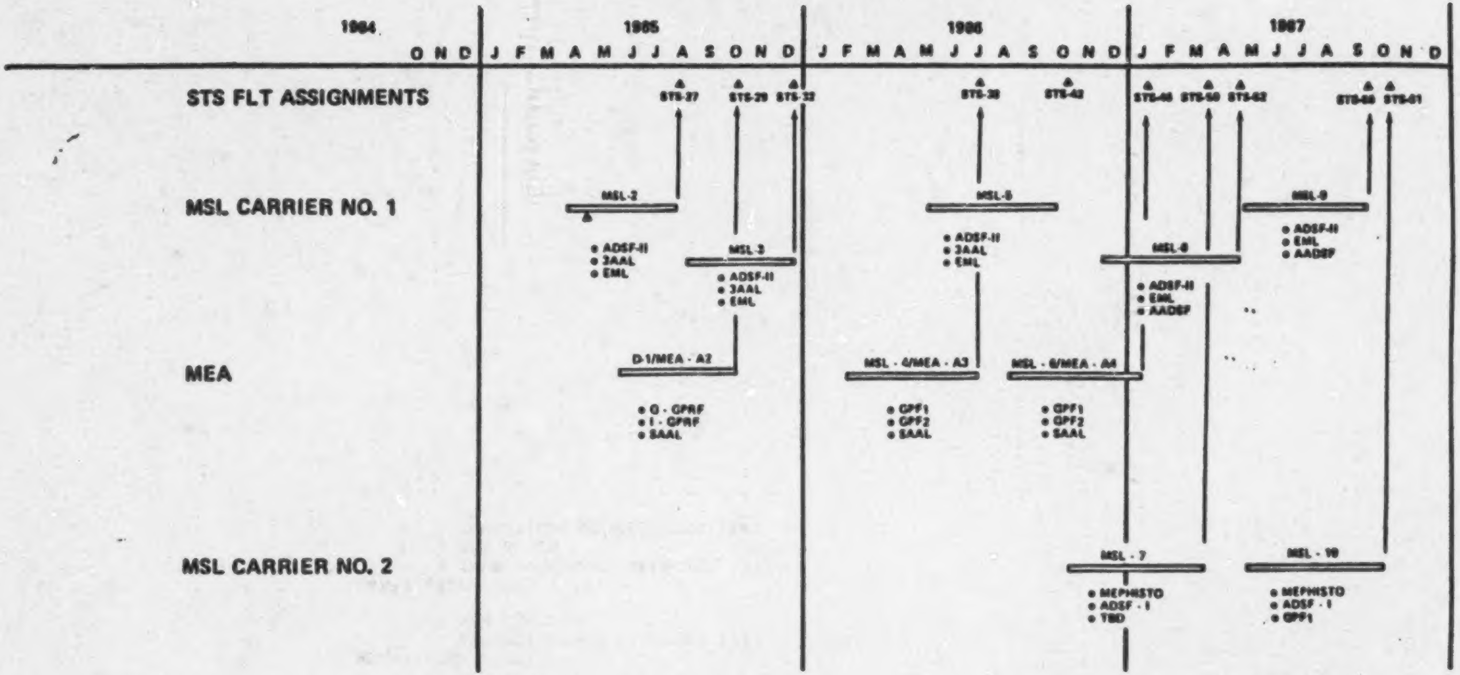
SPACELAB AND CARGO BAY EXPERIMENTS

MSL-7 (MARCH 1987)
- 2 INVESTIGATIONS SELECTED 1977
- 1 INVESTIGATION SELECTED 1983
- 2 NEW SLOTS

MSL-8 (MAY 1987)
- 1 INVESTIGATION SELECTED 1977
- 3 NEW SLOTS

MSL-9 (SEPTEMBER 1987)
- 2 INVESTIGATIONS SELECTED 1977
- 3 NEW SLOTS
- 1 INVESTIGATION SELECTED 1983

MSL FLIGHT ASSIGNMENTS *



* Proposed Nov. 1984 STS baseline dtd 6 Nov. 1984

APPROVED:

——————————— date ———————————
R. E. HALPERN, DIRECTOR
MICROGRAVITY SCIENCES & APPLICATIONS DIV.

——————————— date ———————————
M. J. SANDER, DIRECTOR
SHUTTLE PAYLOAD ENGINEERING DIV.

NASA HQ [illegible] (1)
11-6-84

ESTIMATE OF COSTS INCURRED BY THE MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION THROUGH FLIGHT DELAYS

TYPICAL MIDDECK EXPERIMENTS		
PRINCIPAL INVESTIGATOR		$10-15K/MONTH
HARDWARE		$5-15K/MONTH
	TOTAL	$25K/MONTH
TYPICAL CARRIER FLIGHT		
INVESTIGATORS		$35-45K/MONTH
APPARATUS SUPPORT		$30-50K/MONTH
	TOTAL	$80K/MONTH
SPACELAB III INVESTIGATORS		$30-40K/MONTH
DIVISION IMPACT FY-84		$550K
PROJECTED IMPACT IN FY-85		$2300K

MANAGEMENT SUMMARY

O FLIGHT PROGRAM

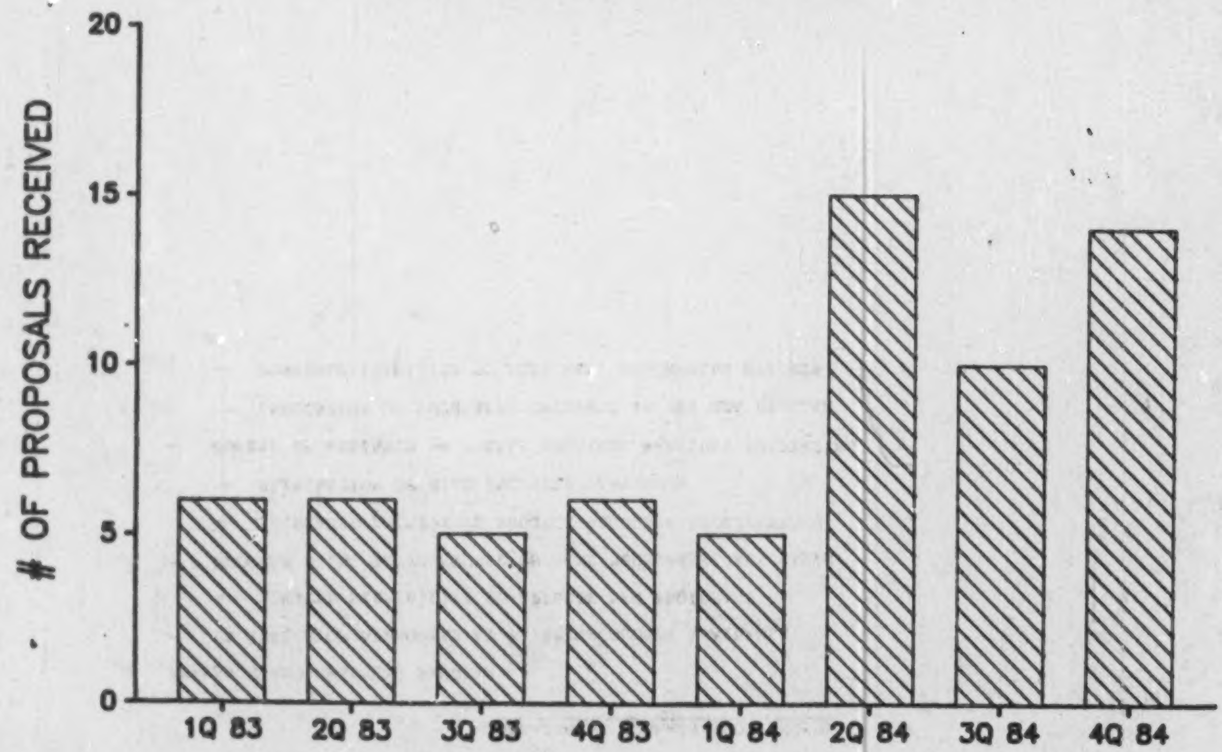
- FUNDS HAVE BEEN REALLOCATED WITHIN THE OSSA PROGRAM TO PROVIDE ADDITIONAL $4M IN FY 1985
    - -- ADDITIONAL FUNDING ENABLES COMPLETION OF APPARATUS ALREADY IN PROCESS AND EQUIPMENT IN DEFINITION PHASE
    - -- FUNDING STILL INADEQUATE FOR ANY NEW INITIATIVES
- BUDGET PLANNING NOW ON A MULTI-YEAR BASIS
    - -- TOTAL PROGRAM ESTIMATES FOR EQUIPMENT APPARATUS AND ACCOMPANYING SCIENCE INVESTIGATIONS
    - -- ABILITY TO PLAN FUTURE PROGRAM/FLIGHT REQUIREMENTS GREATLY ENHANCED
- SEVERAL CENTERS HAVE REORGANIZED TO MORE EFFECIENTLY CONDUCT HARDWARE DEVELOPMENT PROGRAMS FROM BOTH A TECHNICAL AND RESOURCES STANDPOINT
    - -- SYNERGISM BETWEEN HARDWARE DEVELOPERS
    - -- BETTER COORDINATION OF RESOURCE REQUIREMENTS
- SERIES OF IN-DEPTH REVIEWS UNDERWAY TO ENSURE PROPER UTILIZATION OF MANPOWER AND RESOURCES

MANAGEMENT SUMMARY (CONTINUED)

- RESEARCH AND ANALYSIS PROGRAM
  - FY 1985 RTOP APPROVALS AT 96.6% OF BUDGET AVAILABLE
    - LIMITED FLEXIBILITY TO APPROVE NEW PROPOSALS
  - PROGRAM BEING RESTRUCTURED ON MORE "BUSINESSLIKE" BASIS
    - INCREASED ABILITY TO PROJECT RESOURCE REQUIREMENTS
    - ELIMINATION OF HIGH UNCOSTED CARRYOVER
  - NUMBER OF RESEARCH PROPOSALS RECEIVED MARKEDLY INCREASING
    - INDICATION OF INCREASED INTEREST IN THE MSA PROGRAM
    - POSSIBLE INABILITY TO FUND NEW, WORTHWHILE EFFORTS

MICROGRAVITY SCIENCE AND APPLICATIONS

NEW RESEARCH PROPOSALS



MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

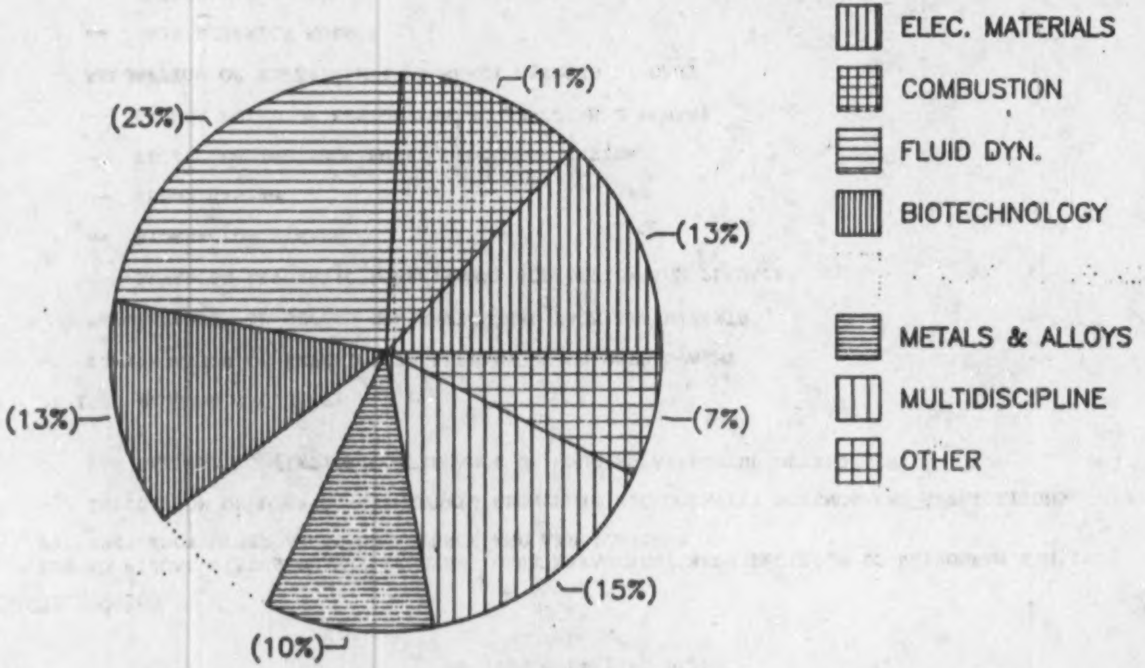
FY 1985 OPERATING PLAN

FLIGHT PROGRAM

- DUE TO FISCAL STATUS OF THE PROGRAM, OSSA MANAGEMENT MADE DECISION TO REPROGRAM $4M IN FY 1985 FROM OTHER AREAS OF SCIENCE AND APPLICATIONS
  - INDICATION OF OSSA COMMITMENT TO GROWTH IN MICROGRAVITY SCIENCE AND APPLICATIONS
  - HAS ALLOWED COMPLETION/CONTINUANCE OF ONGOING APPARATUS DEVELOPMENT
- FY 1985 PROGRAM INCLUDES:
  - CONTINUATION OF EXPERIMENTS ALREADY UNDER DEVELOPMENT
  - "NEW STARTS" OF SECOND GENERATION AND PACE EXPERIMENTS
    - ADVANCED AUTOMATIC DIRECTIONAL SOLIDIFICATION FURNACE
    - BIOREACTOR SYSTEM
    - REDOX SYSTEM
    - RECIRCULATING ISOELECTRIC FOCUSING SYSTEM
    - LAMBDA POINT OF HELIUM (USING SPACELAB 2 DEWAR)
  - ASSUMPTION OF EXPERIMENTS FORMERLY MANAGED BY OAST
    - DROP DYNAMICS MODULE
    - SUPERFLUID HELIUM
  - DEFINITION PHASE ACTIVITY ON HIGH TEMPERATURE ACES
- FY 1985 BUDGET DOES NOT ALLOW FOR DEVELOPMENT OF ANY SECOND OR THIRD GENERATION EQUIPMENT OTHER THAN AADSF

MICROGRAVITY SCIENCE AND APPLICATIONS

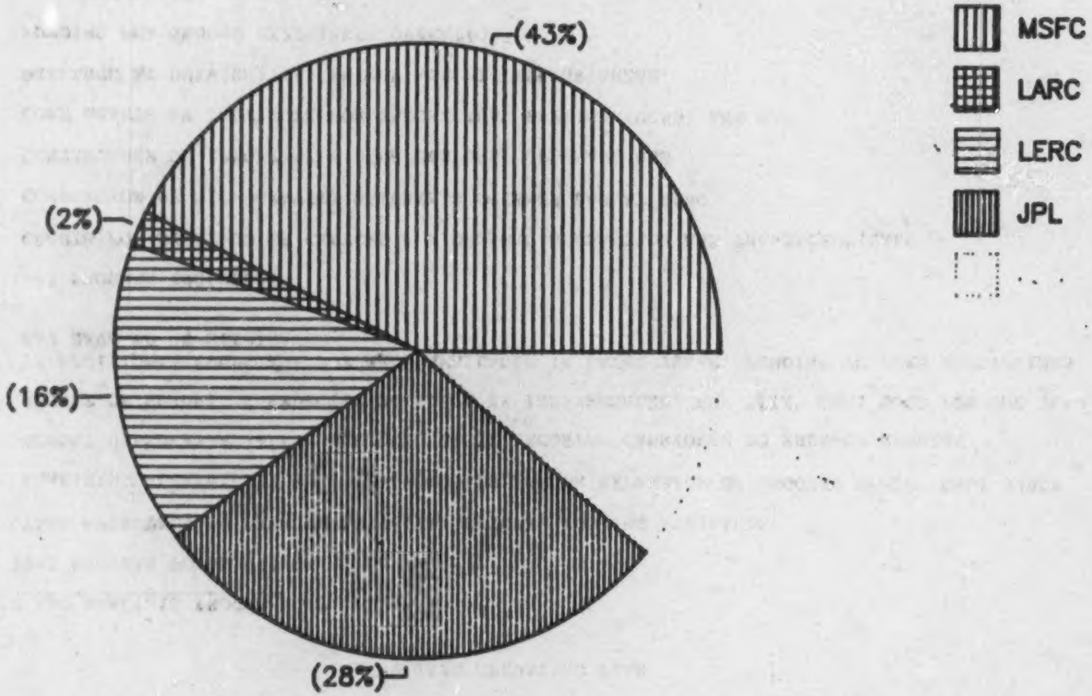
FY 1985 FLIGHT PROGRAM



BREAKDOWN BY DISCIPLINE

MICROGRAVITY SCIENCE AND APPLICATIONS

FY 1985 FLIGHT PROGRAM



BREAKDOWN BY CENTER

MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

FY 1985 OPERATING PLAN

RESEARCH AND ANALYSIS PROGRAM

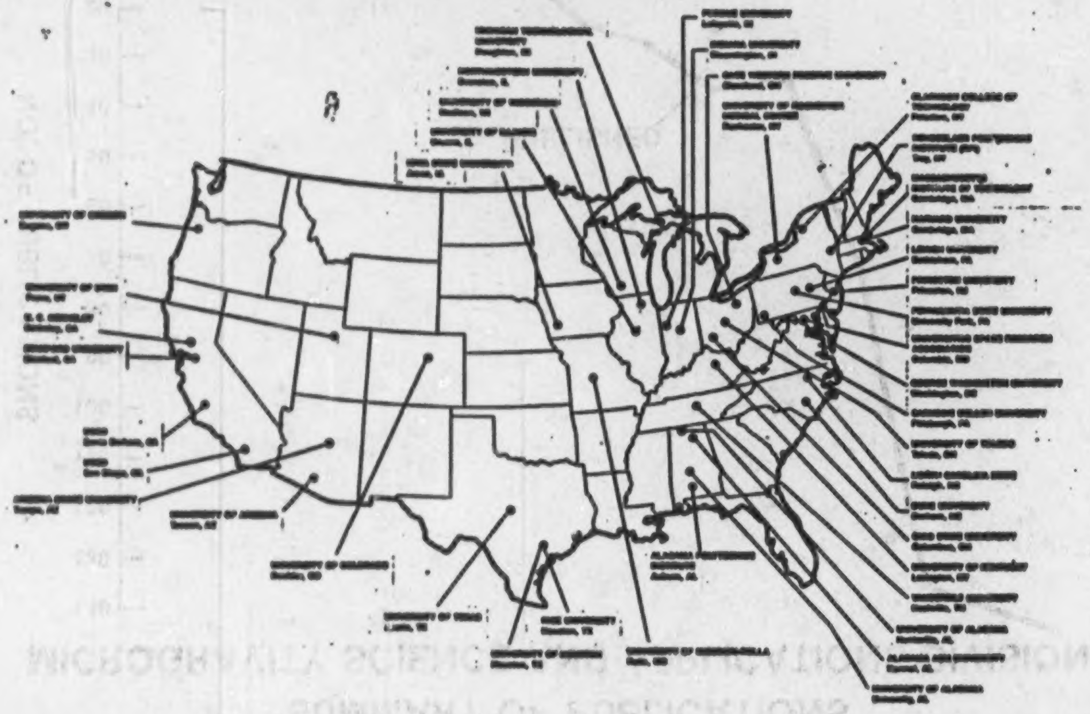
O FY 1985 PROGRAM TOTAL $11.7M

- TASK APPROVALS TO DATE TOTAL 96.6% OF TOTAL FUNDING AVAILABLE
- REMAINING FLEXIBILITY FOR NEW PROPOSALS AND/OR EXPANSION OF ONGOING EFFORT ONLY $400K
- EFFORT UNDERWAY AT ALL CENTERS TO LIMIT UNCOSTED CARRYOVER TO FREE-UP FUNDING
- RESULT OF EFFORT IS EXPECTED TO SOLVE FY 1985 PROBLEM, BUT "FIX" ONLY GOOD FOR ONE YEAR
- IF ADDITIONAL FUNDS ARE NOT MADE AVAILABLE IN LATER YEARS, FUNDING TO SOME DISCIPLINES MAY HAVE TO BE ELIMINATED

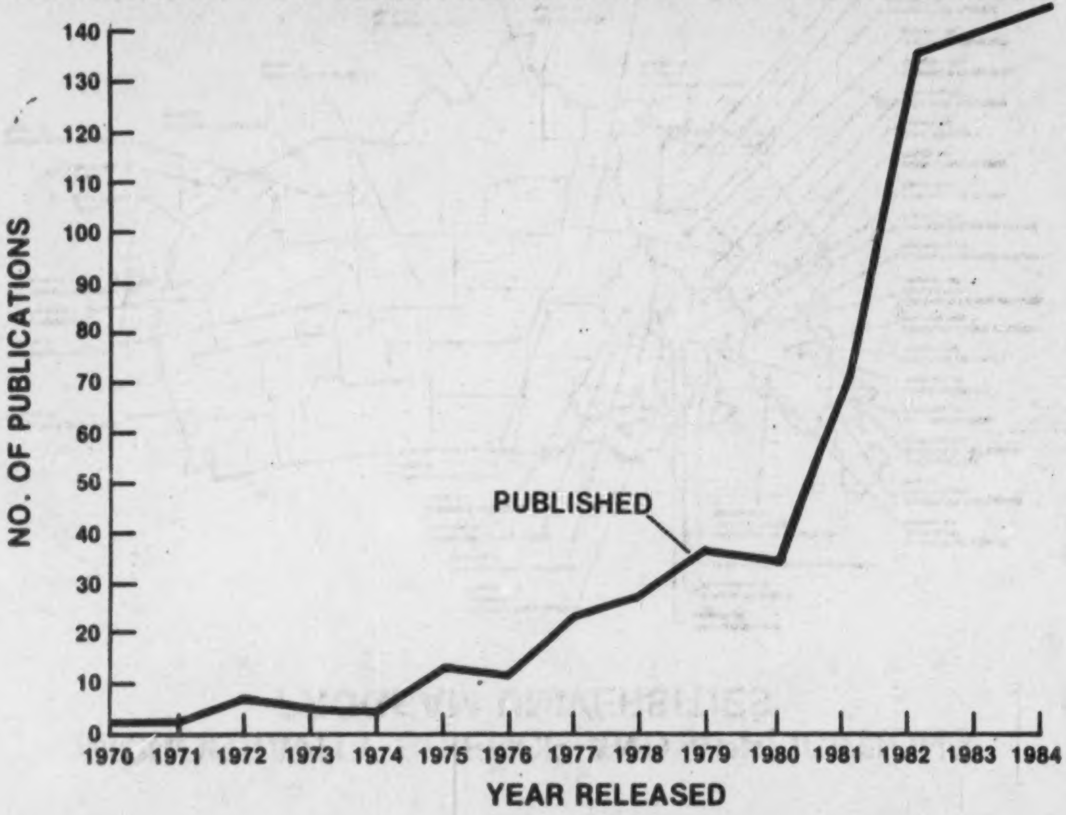
O FY 1985 PROGRAM INCLUDES:

- GRANTS FOR START-UP OF CENTERS FOR ORGANIC SEPARATION AND PHARMACEUTICALS
- COMPLETION OF MICROGRAVITY MATERIALS SCIENCE LAB AT LERC
- CONTINUANCE OF EFFORT AT 4 NASA CENTERS, JPL, AND NBS
- CORE GRANTS AT INSTITUTE FOR THEORETICAL PHYSICS (UCSB) AND MIT
- RESEARCH AT UNIVERSITIES IN THE SIX DISCIPLINE AREAS
- FUNDING FOR GROUND EXPERIMENT OPERATIONS
  - -- DROP TUBES AND DROP TOWERS
  - -- AIRCRAFT FLIGHTS (KC-135, LEAR JET, AND F-104)

MICROGRAVITY SCIENCE AND APPLICATIONS PROGRAM UNIVERSITIES



SUMMARY OF PUBLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION



MICROGRAVITY MATERIALS SCIENCE LABORATORY (MMSL)

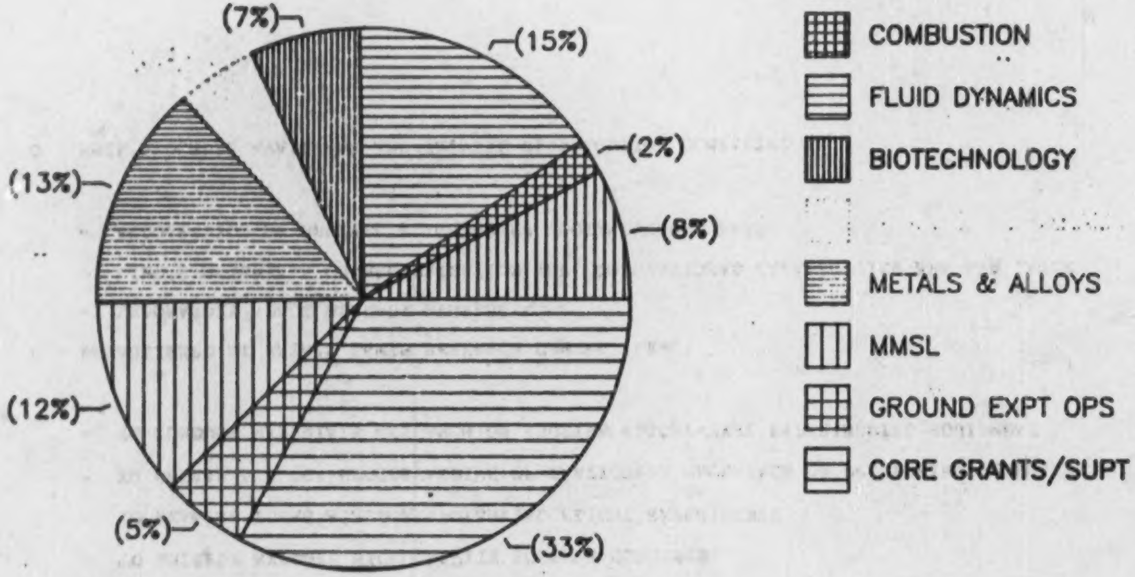
- PROVIDE EASY ACCESS TO INDUSTRY, UNIVERSITY, AND GOVERNMENT RESEARCHERS
  - TO BRIEFLY EXPLORE MICROGRAVITY SCIENCE CONCEPTS
  - TO EXAMINE IDEAS AIMED AT POTENTIAL FLIGHT EXPERIMENTS
  - TO OBTAIN A 1 "G" UNDERSTANDING OF PARTICULAR MATERIALS OR PROCESSING PHENOMENA
  - TO CONDUCT MATERIALS RESEARCH ON SHUTTLE FLIGHT-TYPE EXPERIMENTAL EQUIPMENT

- ESTABLISHED AT NASA'S LEWIS RESEARCH CENTER (LERC)
  - LABORATORY SPACE ALREADY AVAILABLE
  - LERC'S MATERIALS CHARACTERIZATION AND COMPUTATIONAL CAPABILITIES ARE AVAILABLE
  - ACQUISITION OF SHUTTLE FLIGHT-TYPE EQUIPMENT UNDERWAY

- MMSL BROCHURE AVAILABLE AND INITIAL DISTRIBUTION COMPLETED

MICROGRAVITY SCIENCE AND APPLICATIONS

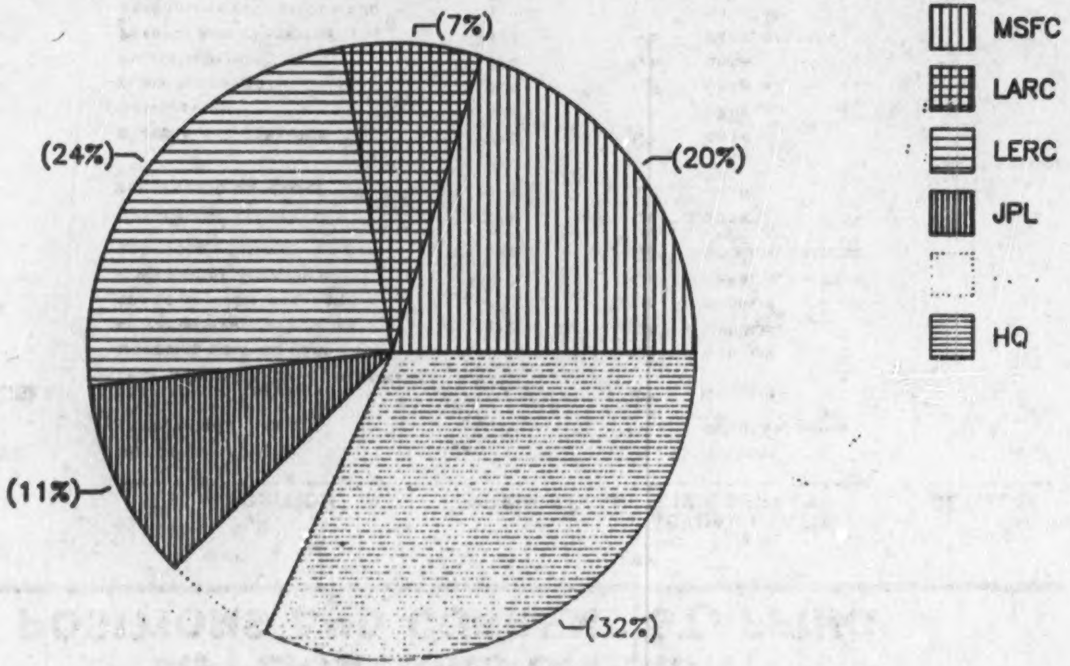
FY 1985 R&A PROGRAM



BREAKDOWN BY DISCIPLINE

MICROGRAVITY SCIENCE AND APPLICATIONS

FY 1985 R&A PROGRAM



BREAKDOWN BY CENTER

MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION POSITIONS AND CURRENT STAFFING

	POSITION	REQUIRED	ACTUAL STATUS CIVIL SERVANT		DETAILEE
ADMINISTRATIVE	DIRECTOR	1	1	HALPERN	
	SECRETARIES	2	2	DOUGLAS, SIMMS	
SHUTTLE/SPACELAB PAYLOADS	PHYSICS AND CHEMISTRY EXPERIMENTS IN SPACE HARDWARE	1	1/6	WRUBLIK	
	MATERIAL SCIENCE HARDWARE	1	1/6	WRUBLIK	
	BIOTECHNOLOGY HARDWARE	1/2	1/6	WRUBLIK	
	SPACE STATION INTERFACE	1	1/6	WRUBLIK	
	COMMERCIAL ACTIVITIES	1	1/6	WRUBLIK, HALPERN	
	ADVANCED PLANNING	1/2	1/6	WRUBLIK, HALPERN	
DISCIPLINES	METALS AND ALLOYS	1/4	1/9	ORAN	
	ELECTRONIC MATERIALS	1/4	1/9	ORAN	COFIELD (supports all discipline areas)
	GLASSES AND CERAMICS	1/4	1/9	ORAN	
	COMBUSTION	1/4	1/9	ORAN	
	FLUID TRANSPORTS	1/4	1/9	ORAN	
	BIOTECHNOLOGY	1/4	1/9	ORAN	
	PHYSICS AND CHEMISTRY	1/3	1/9	ORAN, HALPERN	
	EXPERIMENT OPERATIONS AND DATA ANALYSIS	2/3	1/9	ORAN	
	ADVANCED PLANNING	1/2	1/9	ORAN, HALPERN	
TOTAL		11	5		

CENTERS OF EXCELLENCE IN BIOTECHNOLOGY

O STIMULATE BIOLOGICAL RESEARCH AND PROCESSING IN THE MICROGRAVITY ENVIRONMENT OF SPACE

O 6 PROPOSALS SUBMITTED

O 2 INSTITUTIONS SELECTED

- UNIVERSITY OF ARIZONA, TUCSON, UNDER THE DIRECTION OF M. BIER
- UNIVERSITY CITY SCIENCE CENTER OF PHILADELPHIA, UNDER THE DIRECTION OF P. TODD

O ANNOUNCEMENT RELEASED OCTOBER 19

O PROCUREMENTS INITIATED

- INDIVIDUAL GRANTS OF $450K/YR. TO BE AWARDED
- INITIAL FUNDING INTENDED TO BE "SEED MONEY" WITH ADDITIONAL SUPPORT COMING FROM INDUSTRIAL, EDUCATIONAL, AND OTHER GOVERNMENT SOURCES

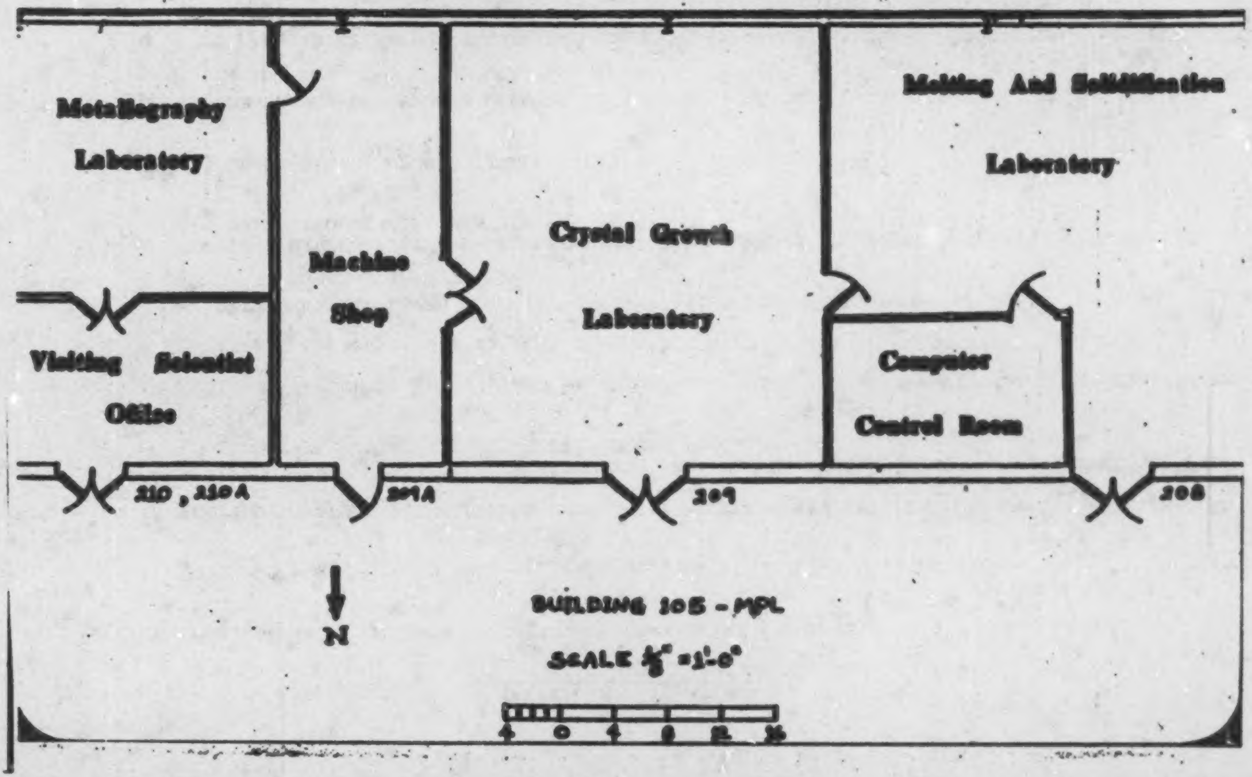
SPACE STATION FY 1985

- OFFICE OF SPACE SCIENCE AND APPLICATIONS (CODE E) SPACE STATION WORKING GROUP (SSWG)
  - WEEKLY MEETINGS
  - INTERACTIONS WITH SESAC TASK FORCE
    - REVIEW CODE E PLAN
    - RECOMMENDATIONS ON CODE E PLAN
    - SUPPORT TO SUMMER STUDY
  - DEVELOP MISSION SETS TO SUPPORT JSC SYSTEMS ANALYSIS EFFORT
  - REVIEW SPACE STATION DESIGN AGAINST USER REQUIREMENTS
  - SUPPORT MISSION REQUIREMENTS WORKING GROUP AND UPDATE MISSIONS PERIODICALLY
  - INTERFACE/WORK WITH APPROPRIATE CENTER WORK PACKAGE PERSONNEL
- MSAD EFFORTS
  - HOLD A MSAD REQUIREMENTS DEFINITIONS WORKSHOP
  - AWARD CONTRACT FOR MMPF STUDY
    - RECEIVE SCIENCE AND APPLICATIONS REQUIREMENTS AND SYNTHESIZE RESULTS
    - DETERMINE INITIAL BASELINE PAYLOADS AND DETERMINE MISSION REQUIREMENTS
    - PROVIDE UPDATED MISSION REQUIREMENTS TO SPACE STATION PHASE B CONTRACTORS
    - PERFORM POWER, OPERATIONS, AND MISSION TIMELINES
    - PERFORM CONCEPTUAL DESIGN OF PAYLOADS AND PRELIMINARY COST ESTIMATE
  - MAINTAIN OVERSIGHT EFFORT FOR GUIDANCE OF MMPF CONTRACT
  - MAINTAIN INTERACTIONS WITH SCIENTIFIC COMMUNITY

MATERIALS SCIENCE IN SPACE

Lewis Research Cent

Micro-Gravity Materials Science Laboratory


Metallography Laboratory
Machine Shop
Crystal Growth Laboratory
Melting And Solidification Laboratory
Visiting Scientist Office
Computer Control Room
210, 210A
209A
209
208
N
BUILDING 105 - MPL
SCALE 1/8" = 1'-0"
4
0
4
8
12
16

COMMERCIAL OPERATIONS FY 1985

- CONTINUE INTERACTION WITH OFFICE OF COMMERCIAL PROGRAMS
- CONTINUE WORKING WITH HEAD OF SPACE STATION COMMERCIAL WORKING GROUP
- CONTINUE RESPONSIBILITIES FOR COMMERCIAL MICROGRAVITY APPLICATIONS OF THE MSAD PROGRAM
  - EXPAND THE NUMBER OF JOINT ENDEAVOR AGREEMENTS, TECHINCAL EXCHANGE AGREEMENTS, AND INDUSTRIAL GUEST INVESTIGATORS IN THE PROGRAM
- CONTINUE CENTER SCIENTIFIC AND ENGINEERING INVOLVEMENT WITH POTENTIAL COMMERCIAL USERS
  - EXPAND NUMBER OF VISITS TO AND FROM POTENTIAL USERS
  - GET POTENTIAL USERS MORE INVOLVED, PERHAPS THRU WORKSHOPS
- CONTINUE DEVELOPMENT AND DISTRIBUTION OF BROCHURES, TECHNICAL APPARATUS DATA SHEETS AND OTHER PROGRAM INFORMATION
- ENCOURAGE USE OF GROUND TEST FACILITIES
- ENCOURAGE USE OF LERC MICROGRAVITY MATERIALS SCIENCE LABORATORY
- ENCOURAGE INPUTS/INVOLVEMENT IN THE MICROGRAVITY AND MATERIALS PROCESSING FACILITY STUDY BY POTENTIAL USERS

CURRENT MSA JOINT AGREEMENTS

JOINT ENDEAVOR AGREEMENTS (JEA)

- MCDONNELL-DOUGLAS AEROSPACE CORPORATION - CONTINUOUS FLOW ELECTROPHORESIS
- MICROGRAVITY RESEARCH ASSOCIATES - GALLIUM ARSENIDE ELECTROEPITAXY GROWTH
- 3M CORPORATION - SOLIDIFICATION OF ELECTRO-OPTICAL MATERIALS

TECHNICAL EXCHANGE AGREEMENTS (TEA) OR EQUIVALENT

- HONEYWELL - MERCURY CADMIUM TELLURIDE PURIFICATION
- DEERE & COMPANY - STUDY OF CAST IRON
- ALCOA - SPHERICAL SHELL TECHNOLOGY
- SANDIA LABS - FUSION TARGET TECHNOLOGY
- CENTER FOR BLOOD RESEARCH/HARVARD MEDICAL COLLEGE - LOW GRAVITY BLOOD STORAGE
- ARGONNE NATIONAL LABORATORY - YTTRIUM OXIDE SOLIDIFICATION STUDIES

NEW MSA JOINT INITIATIVES UNDER DISCUSSION

KMS FUSION - FUSION SHELL TARGET FORMATION

CELANESE CORP.- POLYMER PROCESSING RESEARCH

BIODYNE, INC. - PRODUCTION OF PURE SILICON CRYSTALS

CORNING GLASS - BASIC RESEARCH IN METALLIC GLASSES

SPECIAL METALS, INC. - SUPERALLOY SOLIDIFICATION RESEARCH

GTE LABORATORIES - GALLIUM ARSENIDE CRYSTAL GROWTH

GENERAL MOTORS - CERAMIC RESEARCH

UPJOHN LABORATORIES - PROTEIN CRYSTAL GROWTH

SCIENCE APPLICATION, INC. - VAPOR DEPOSITION

SCHERING CORPORATION - PROTEIN CRYSTAL GROWTH

TELE-OPTIK - PRODUCTION OF HIGH TRANSMISSION GLASS FIBERS

DSMA ATCAN, LTD. (CANADA) - SOLIDIFICATION STUDIES

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

PACE EXPERIMENTS CRITICAL PHENOMENA

EXPERIMENT	LOCATION	INVESTIGATOR	SPONSORING CENTER	STATUS
Specific Heat of Helium Through the Lambda Point	Stanford Univ.	W. Fairbank J. Lipa	JPL	SRR Comp. CoDR-Sept. 84
Light Scattering Tests of Fundamental Theories of Transport Properties in the Critical Region	National Bureau of Standards	M. Moldover	LeRC	CDP
Precise Viscosity Measurements Very Close to Critical Points	National Bureau of Standards	M. Moldover	LeRC	CDP
Critical Transport Phenomena in Fluid Helium Under Low Gravity	Duke Univ.	H. Meyer R. Behringer	GSFC	CDP

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

PACE EXPERIMENTS
FLUID PHYSICS

EXPERIMENT	LOCATION	INVESTIGATOR	SPONSORING CENTER	STATUS
Electrohydrodynamics	Princeton	D. Saville	LeRC	CDP
Surface-Tension Driven Convection Under Reduced Gravity Conditions	Case Western Reserve Univ.	S. Ostrach Y. Kamotani	LeRC	CDP
Free Surface Phenomena Under Low and Zero-Gravity Conditions	Case Western Berkeley Calif. Tech	P. Concus R. Finn D. Coles	LeRC	CDP
Surface Tension Induced Instabilities In Reduced Gravity: The Benard Problem	Univ. of Texas LeRC	E. Koschmieder A. Chai	LeRC	CDP
Mass Transport Phenomena Between Bubbles and Dissolved Gases in Liquids Under Reduced Gravity Conditions	Univ. of Toledo	K. Dewitt	LeRC	CDP
Test of New Thermodynamic Model of Impurity Extraction by Droplets	The National Bureau of Standards	G. Morrison J. Kinkaid	LeRC	CDP

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

PACE EXPERIMENTS

EXPERIMENT	LOCATION	INVESTIGATOR	SPONSORING CENTER	STATUS
COMBUSTION				
Solid Surface Combustion	Univ. of Kentucky	R. Altenkirch	LeRC	CoDR Comp Entering FDP
Gas Jet Diffusion Flame	Science Applications	P. Harsha R. Edelman	LeRC	CDP
RELATIVITY				
Cryogenic Equivalence Principle	Stanford Univ.	F. Everitt P. Worden	MSFC	CDP
PARTICLE MECHANICS				
Particle Behavior Under Very Low Intergranular Stresses	Univ. of Colorado	S. Sture	MSFC	CDP

MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION (MSAD) ACCOMPLISHMENTS FY 1984

- COMPLETED A COMPREHENSIVE 5 YEAR PLAN
- COMPLETED REALIGNMENT OF BUDGET PRACTICES
- SELECTED 2 CENTERS FOR ORGANIC SEPARATION AND PHARMACEUTICAL RESEARCH - 6 PROPOSALS RECEIVED
- COMPLETED FIRST MSAD ANNUAL REPORT TO CONGRESS
- PARTICIPATED IN VARIOUS SYMPOSIA AS SPEAKER/SESSION CHAIRMAN
- COMPLETED FINAL REVIEW OF UPDATED APPARATUS HANDBOOK
- GENERATED VARIOUS BROCHURES AND PAMPHLETS
- STARTED MICROGRAVITY MATERIALS SCIENCE LABORATORY (MMSL) AT LERC
- PHYSICS AND CHEMISTRY EXPERIMENTS (PACE) BROUGHT INTO MSAD PROGRAM
- ESTABLISHMENT OF DISCIPLINE WORKING GROUPS
- COMPLETED CONCEPTUAL DESIGN REVIEW OF 2 PACE EXPERIMENTS

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

METALS AND ALLOYS

RESEARCH AREA	THRUST
MONOTECTICS	InAl & TeTl, GELLES/GELLES ASSOCIATES
	PHASE SEPARATION, FRAZIER/MSFC
EUTECTICS	MODELING, WILCOX/CLARKSON
	MnBi & CoSm, LARSON/GRUMMAN
	MAGNETIC FIELD EFFECT, PIRICH/GRUMMAN
UNDERCOOLING	EM FIELD EFFECTS, SZEKELY/MIT
	NI BASE ALLOYS, FLEMINGS/MIT
	NbGe, BAYUZICK/VANDERBILT UNIVERSITY
	MARTENSITIC STEEL, COLLINGS/BATTELLE
	NI, PEREPEZKO/UNIVERSITY OF WISCONSIN
	CONTAINERLESS TECHNIQUES, TRINH/JPL
	METALLIC GLASS, KOCH/NC STATE
SOLIDIFICATION FUNDAMENTALS	BINARY ALLOY SOLIDIFICATION, LAXMANAN/CWRU/LeRC
	DENDRITE GROWTH, GLICKSMAN/RPI
	SEGREGATION, HELLAWELL/MTV
	INTERFACE STABILITY, CORRIELL/NBS
	THEORETICAL STUDIES, KOHN/ITP, UCSB
THERMOPHYSICAL PROPERTIES	THEORETICAL MODELING, STROUD/OHIO STATE
	SPECIFIC HEATS, MARGRAVE/RICE
	CALORIMETRY TECHNIQUES, BONNELL/NBS
	PULSE CALORIMETRY, CEZAIRLIYAN/NBS

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

GLASSES AND CERAMICS

RESEARCH AREA	THRUST
NEW GLASS COMPOSITIONS	FLOURIDE GLASSES, DOREMUS/RPI
	OXIDE GLASSES, DAY/UNIVERSITY OF MISSOURI
	SOL GEL GLASSES, MUKHERJEE/JPL
	HIGH TEMPERATURE MELTS, ETHERIDGE/MSFC
FINING	BUBBLE REMOVAL, SUBRAMANIAN/CLARKSON
	MODELING, WEINBERG/JPL
	SURFACE TENSION EFFECTS, UHLMANN/MIT
SPHERICAL SHELL	SPHERICAL SHELL TECHNOLOGY, WANG/JPL
	PRECURSOR MATERIALS, DOWNS/KMS

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

BIOTECHNOLOGY

RESEARCH AREA	THRUST
NEW TECHNIQUE DEVELOPMENT	ELECTROPHORESIS MODEL, SAVILLE/PRINCETON
	ISOELECTRIC FOCUSING, BIER/UNIVERSITY OF ARIZONA
	CELL PARTITIONING, BROOKS/OREGON
EVALUATION OF CFES	ELECTROPHORESIS, SNYDER/MSFC
	GROWTH HORMONE, HYMER/PENN STATE
	KIDNEY CELLS, MORRISON/JSC
	PROTEINS, SNYDER/MSFC
	CHARACTERISTICS OF KIDNEY CELL GROWTH, TODD/PENN STATE

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

ELECTRONIC MATERIALS

RESEARCH AREA	THRUST
VAPOR GROWTH	FLOW MODELING, ROSENBERGER/UNIVERSITY OF UTAH
	MASS TRANSPORT, WEIDEMEIER/RPI
	GeSe (MODEL MAT.), WEIDEMEIER/RPI
	HgCdTe, WEIDEMEIER/RPI
	HgI_2, SCHNEPPLE/EG&G
	CVD, STINESPRING/AERODYNE/SPEAR/PENN STATE
MELT GROWTH	FLOW MODELING, BROWN/MIT
	GaAs, GATOS/MIT
	THERMAL MODEL, LEHOCZKY/MSFC
	HgCdTe, LEHOCZKY/MSPC
	PbSnTe, CROUCH/LARC
	INTERFACE STABILITY, CORIELL/NBS
	INTERFACE CONTROL, WITT/MIT
	GeSe, CdTe, WITT/MIT
	GaAl KAs, BACHMAN/NC STATE
SOLUTION GROWTH	TGS, LAL/ALABAMA A&M
	PROTEIN GROWTH, FEIGELSON/STANFORD
	ORGANIC CONDUCTORS, HEEGER/UCSB
FLOAT ZONE	TECHNIQUES AND ANALYSIS, KERN/WESTEC
	PROPERTIES OF SI, HARDY/NBS
	OXIDE SKIN FORMATION, VERHOEVEN/IOWA STATE

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

COMBUSTION SCIENCE

THRUST	
LEAN LIMIT FLAMES	STREHLOW/UNIVERSITY OF ILLINOIS
SMOLDERING	PAGNI/UC-BERKELEY
DROPLET BURNING	WILLIAMS/PRINCETON
PARTICLE CLOUD	BERLAD/UCSD
FLAME SPREADING	ALTENKIRCH/UNIVERSITY OF KENTUCKY
GAS JET DIFFUSION	HARSHA/SAI
POOL BURNING	SIRIGNANO/CARNEGIE-MELLON

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

FLUID DYNAMICS AND TRANSPORT PHENOMENA

RESEARCH AREA	THRUST
CRITICAL POINT PHENOMENA	TRANSPORT PHENOMENA IN He, MEYER/DUKE
	MEASUREMENT TECHNIQUES, MOLDOVER/NBS
	THREE PHASE SYSTEMS, MOLDOVER/NBS
	SPECIFIC HEAT OF He, LIPA/STANFORD
SURFACE BEHAVIOR	MARANGONI FLOW INSTABILITY ONSET, DAVIS/NORTHWESTERN
	SURFACE TENSION DRIVEN FLOW, OSTRACH/CWRU
	SURFACE EFFECTS OF FORCED FLOW, YETJEVICH/GWU
	FREE SURFACE PHENOMENA, CONCUS/CWRU
	INSTABILITIES, KOSCHMIEDER/U OF TEXAS, CHAI/LeRC
CHEMICAL REACTION	MONODISPERSE LATEX, VANDERHOFF/LEHIGH
CLOUD PHYSICS	THERMODIFFUSIVE TRANSPORT, ANDERSON/MSFC
	NUCLEATION AND GROWTH, HALLETT/DRI
RELATIVITY	CRYOGENIC EQUIVALENCE PRINCIPLE, EVERITT/STANFORD

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

FLUID DYNAMICS AND TRANSPORT PHENOMENA (CONTINUED)

RESEARCH AREA	THRUST
TRANSPORT PHENOMENA	CRYSTAL GROWTH, CHAI/LeRC
	THERMODIFFUSOCAPILLARY FLOW, KLIMEK/LeRC
	INTERFACE STUDIES, SAVILLE/PRINCETON
	THERMODIFFUSOCAPILLARY FLOW, NEITZEL/ARIZONA STATE
	DIFFUSION EFFECTS, DEWITT/U OF TOLEDO
	THERMODIFFUSOCAPILLARY, SANI/U OF COLORADO

MSA DISCIPLINE WORKING GROUPS

o RESTRUCTURE COMMITTEES TO EXPAND SCOPE AND FOCUS ON SCIENTIFIC QUESTIONS

- IDENTIFY RESEARCH AREAS OF EACH DISCIPLINE AND DETERMINE RATIONALE FOR MICROGRAVITY EXPERIMENTS BOTH FOR BASIC SCIENCE AND THOSE HAVING POTENTIAL APPLICATIONS
- ENCOURAGE QUALIFIED INVESTIGATORS TO PARTICIPATE IN PROGRAM
- TENTATIVE CHARTERS GENERATED IN NOVEMBER; COMMITTEE MEMBERS ESTABLISHED FEBRUARY; FIRST MEETING HELD IN MAY

o OVERSIGHT COMMITTEE TO BE ESTABLISHED FOR BOTH SCIENCE PROGRAM AND COMMERCIAL INVESTIGATIONS

OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

DISCIPLINE WORKING GROUP MEMBERSHIP

BIOTECHNOLOGY		
Interim Chairman:	P. Todd	Penn State
Vice Chairman:	D. Morrison	JSC
	G. V. F. Seaman	Univ. of Oregon
	P. Lacey	Wash. Univ., St. Louis
	M. Bier	Univ. of Arizona
	D. Richmond	MDAC
	R. Snyder	MSFC
	1 additional from industry	
COMBUSTION SCIENCE		
Interim Chairman:	A. Berlad	UC, San Diego
Vice Chairman:	K. Sacksteder	LeRC
	P. Myers	Univ. of Wisconsin
	H. Palmer	Penn State
	S. Penner	UC, San Diego
	R. Strehlow	Univ. of Illinois
	F. Williams	Princeton
	W. Bartok	Exxon Res. Labs
	B. Levine	NBS
	W. Agnew	GM Research Labs.
ELECTRONIC MATERIALS		
Interim Chairman:	A. Witt	MIT
Vice Chairman:	A. Lehoczky	MSFC
	K. Bachmann	N. Carolina State
	H. Gatos	MIT
	J. Verhoeven	Iowa State
	W. Wilcox	Clarkson College
	L. Jastrzebski	RCA
	H. Rupprecht	IBM
	R. Shaw	Texas Instruments
	F. Kohl	LeRC
	R. Crouch	LeRC

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

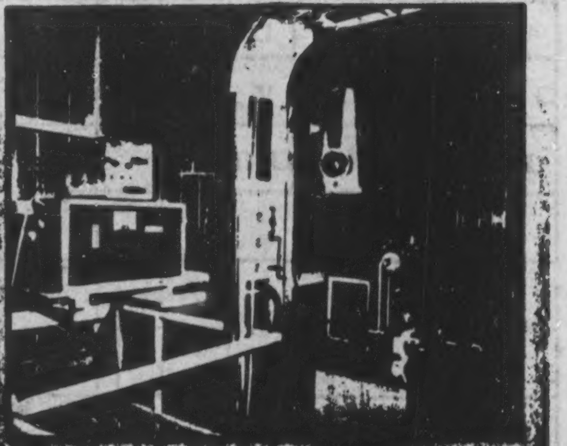
DISCIPLINE WORKING GROUP MEMBERSHIP (CONT'D)

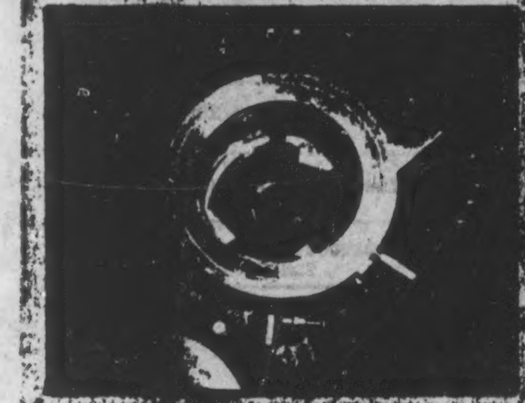
FLUID DYNAMICS AND TRANSPORT PHENOMENA		
Interim Chairman:	J. Szekeley	MIT
Vice Chairman:	T. Labus	LeRC
	J. Lipa	Stanford
	T. Hanratty	Univ. of Illinois
	F. Rosenberger	Univ. of Utah
	D. Saville	Princeton
	J. Hart	Univ. of Colorado
	W. Langlois	IBM
	R. Melnick	Grumman
	W. Fowlis	MSFC
GLASSES & CERAMICS		
Interim Chairman:	R. Doremus	RPI
Vice Chairman:	M. Weinberg	JPL
	D. Uhlmann	MIT
	D. Day	Univ. of Mo.-Rolla
	N. Kreidl	Univ. of New Mexico
	E. Snitzer	United Technologies
	S. Prochazka	GE
	S. Grisaffe	LeRC
	E. Ethridge	MSFC
METALS & ALLOYS		
Interim Chairman:	M. Glicksman	RPI
Vice Chairman:	R. Naumann	MSFC
	R. Pond	Johns Hopkins Univ.
	J. Perepezko	Univ. of Wisconsin
	J. Dantzig	Univ. of Illinois
	J. Cahn	NBS
	F. Lemkey	United Technologies
	K. Jackson	Bell Labs
	D. Larson	Grumman
	T. Wang	JPL

DROP TUBE FACILITY

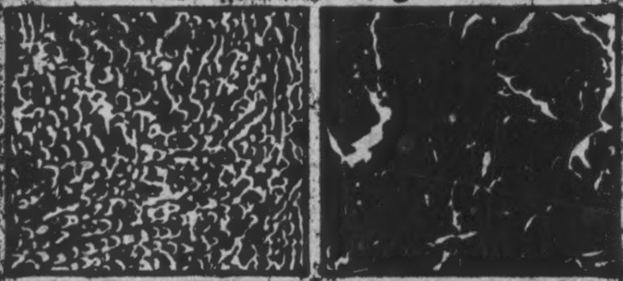
ONLY SAMPLE IS DROPPED

ZERO G TIME	4.5 SEC
HEIGHT	[illegible]
TUBE DIAMETER	30 cm
SAMPLE MASS	[illegible]
VACUUM LEVEL	10^{-6} TORR
GAS	ARGON HYDROGEN HELIUM





DROP TUBE PROCESSED [illegible] [illegible]



HIGH COOLING RATE ([illegible] mm DIAMETER)

LOW COOLING RATE (1.7 mm DIAMETER)

JA62

MARSHALL SPACE FLIGHT CENTER
DROP TUBE & DROP TOWER
PROJECTED SCHEDULE

R. BLACK
NOV. 9, 1984

	1984							1985				
	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
DR. COLLINGS BATTELLE LABORATORY	■						□	□	□ □	□	□	□
DR. BAYUZICK VANDERBILT UNIVERSITY	■					□	□	□	□		□	□
DR. LAXMANAN CASE WESTERN						□	□	□	□	□	□	□
DR. PEPEPEZKO UNIV. OF WISCONSIN	■	CLOSED for MODIFICATION and REPAIR				□		□		□		□
DR. ETERIDGE MSFC						□		□	□	□	□	□
MR. ROBINSON MSFC								□	□	□	□	□
DR. KING ARGONNE NATIONAL LABORATORIES						□	□		□	□ □		□
DR. KOCH N. C. STATE UNIV.									□	□	□	□
DR. JEMIAN AUBURN UNIVERSITY							□	□ □		□	□	□
DR. WU UNIV. OF AL IN HUNTSVILLE						□		□	□	□	□	□
DROP TOWER DR. WU UNIV. OF AL IN HUNTSVILLE						□		□	□	□		□
DROP TOWER DR. KAUKLER UNIV. OF AL IN HUNTSVILLE	■					□		□ □		□	□	□

KC-135 AIRCRAFT SIMULATION REQUIREMENTS

	EXPERIMENTER'S NAME	EXPERIMENT OR TEST	FY85											
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	Wang/Ellerman - JPL	Three Axis Acoustic Levitator (Support of Scheduled Flights, 3AAL 1985 and Shuttle Flights through 1988, ACES and DDM)		●	●	●		●		●				●
	Val Fogle	3 Axis Air Jet Levitator		●					●				●	
	Frazier/Owen/Shurney	Critical Point Wetting Immiscible				●		●			●			●
	V. Arp/ P. Giarratano - NBS (Owen/Shurney)	Low Gravity Study in Heat and Mass Transfer		●					●		●			●
	Owen/Johnston/Kroes	FES Scientific & Engineering Support Spacelab 3			●				●					
	Owen/Poteet	Official Visualization of Fluid Flow												
	M. Johnston/Owen	Metal Model Material (Zeiss Microscope Study)		●		●			●					
	M. Johnston	Study of Super Alloy/Metal-Model Material			●			●		●			●	
	Van Alstine/Curreri	Phase Partitioning (Biotechnological Isolation)												
**	Curreri/Shurney	Metal Alloy Directional solidification				●			●		●			●
	Wilcox(Clarkson College)	Develop Analog for Directional Solidification		●				●			●			●
	Cole(Clarkson College)	Physical Phenomena in Containerless Glass Process		●		●			●				●	
	Cezairliyan (NBS)	Dynamic Thermophysical Measurements in Space				●		●		●			●	
	Frazier/Shurney/Owen	Foam Decay in Low Gravity								●	●		●	●
**	Leslie/Schaffer	FIBEX			●			●		●			●	
*	Spacelab 2 B. Cobb	Crew Training			●									
**	Goldberg/Clinton	Polymer Crystallization				●		●		●	●		●	●

*Spacelab one-time flight for crew

**Center Director's Discretionary Fund (CDDF)

October 1984

CURRENT MICROGRAVITY FACILITY USAGE WITH RESPECT TO MSAD PROGRAMS LEWIS RESEARCH CENTER

A. 2.2-Second Drop Tower

	Experiment	P.I.	Frequency
1)	Interface Stability	M. Carney/A.Chai	2/week
2)	Thermodiffusocapillary Flow	T. Peterson	2/week
3)	Flammability Limits	Dr. P. Ronney	10/week
4)	G-Jitter	Dr. S. Ostrach/ L. Sarsfield	1/week
5)	Particle Cloud Hardware	D. Vento/R. Klimek	2/week

B. LeRC Lear Jet

	Experiment	P.I.	Frequency
1)	Liquid Inflow	Dr. S. Ostrach/ L. Sarsfield	12/month
2)	Flammability Limits	Dr. Strehlow/ K. Sacksteder	12/month
3)	Mass Transfer	Dr. DeWitt/ T. Peterson	6/month

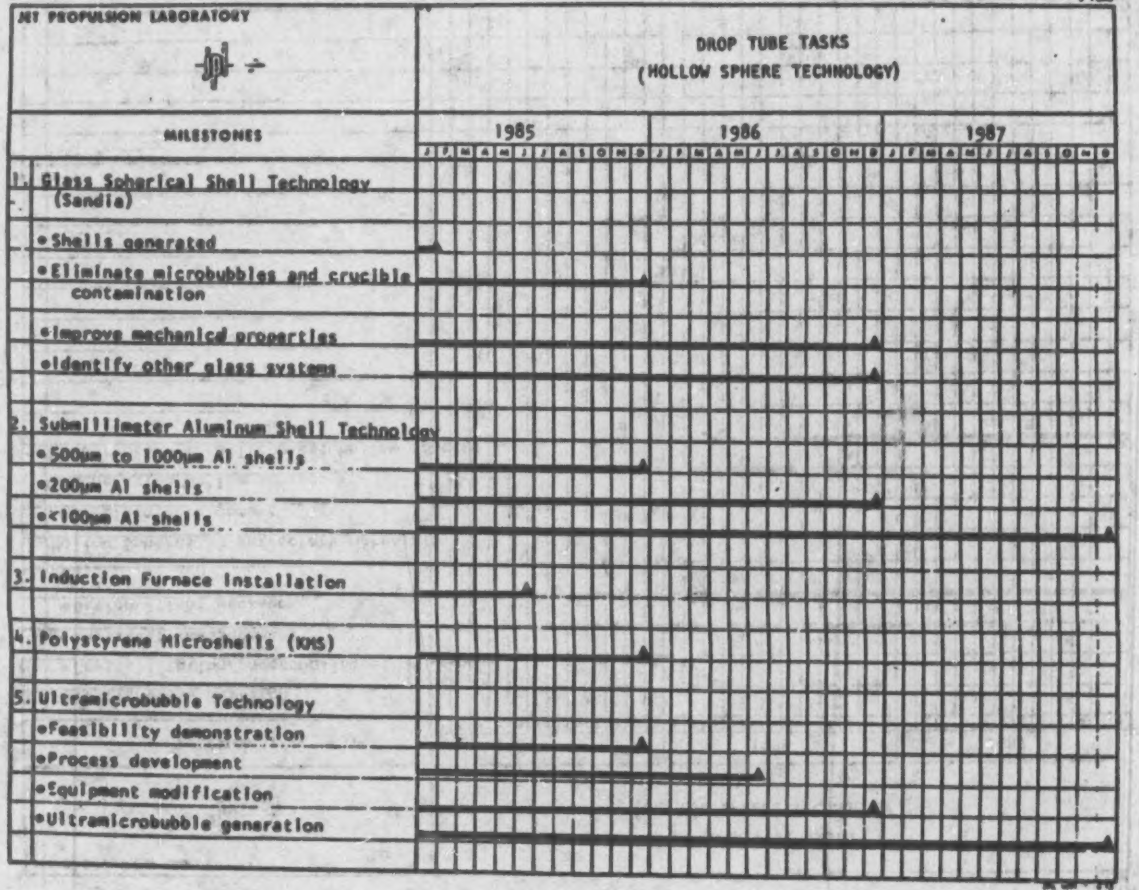
C. 5-Second Zero Gravity Facility

	Experiment	P.I.	Frequency
1)	Thermodiffusocapillary Flow	T. Peterson	2/week
2)	Solid Surface Ignition	R. Zavesky	2/week

Thomas L. Labus
11/9/84

MARK C. LEE 11/09/84

Pg 1 of 2



JET PROPULSION LABORATORY

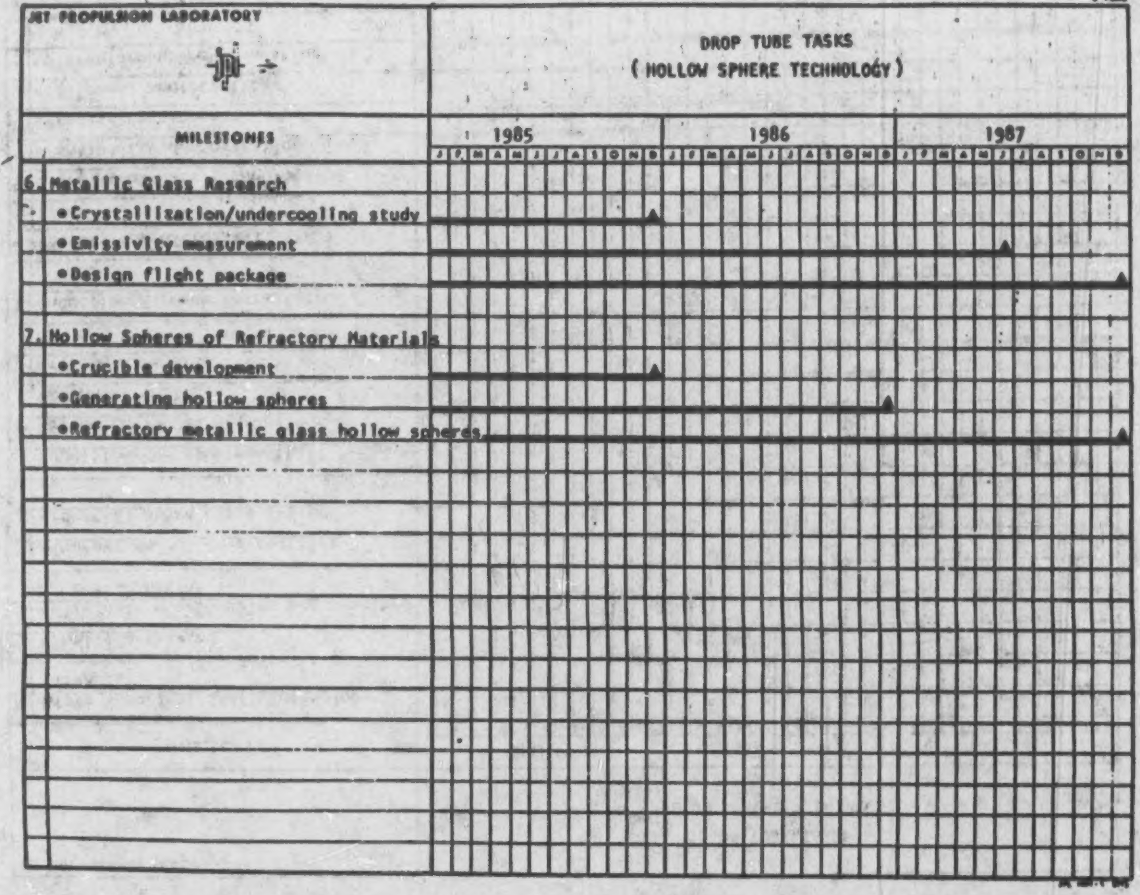
DROP TUBE TASKS
(HOLLOW SPHERE TECHNOLOGY)

MILESTONES

1. Glass Spherical Shell Technology (Sandia)
    - Shells generated
    - Eliminate microbubbles and crucible contamination
    - Improve mechanical properties
    - Identify other glass systems
2. Submillimeter Aluminum Shell Technology
    - 500µm to 1000µm Al shells
    - 200µm Al shells
    - <100µm Al shells
3. Induction Furnace Installation
4. Polystyrene Microshells (KMS)
5. Ultramicrobubble Technology
    - Feasibility demonstration
    - Process development
    - Equipment modification
    - Ultramicrobubble generation

1985
1986
1987
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

MARK C. LEE 11/09/84 Pg 2 of 2

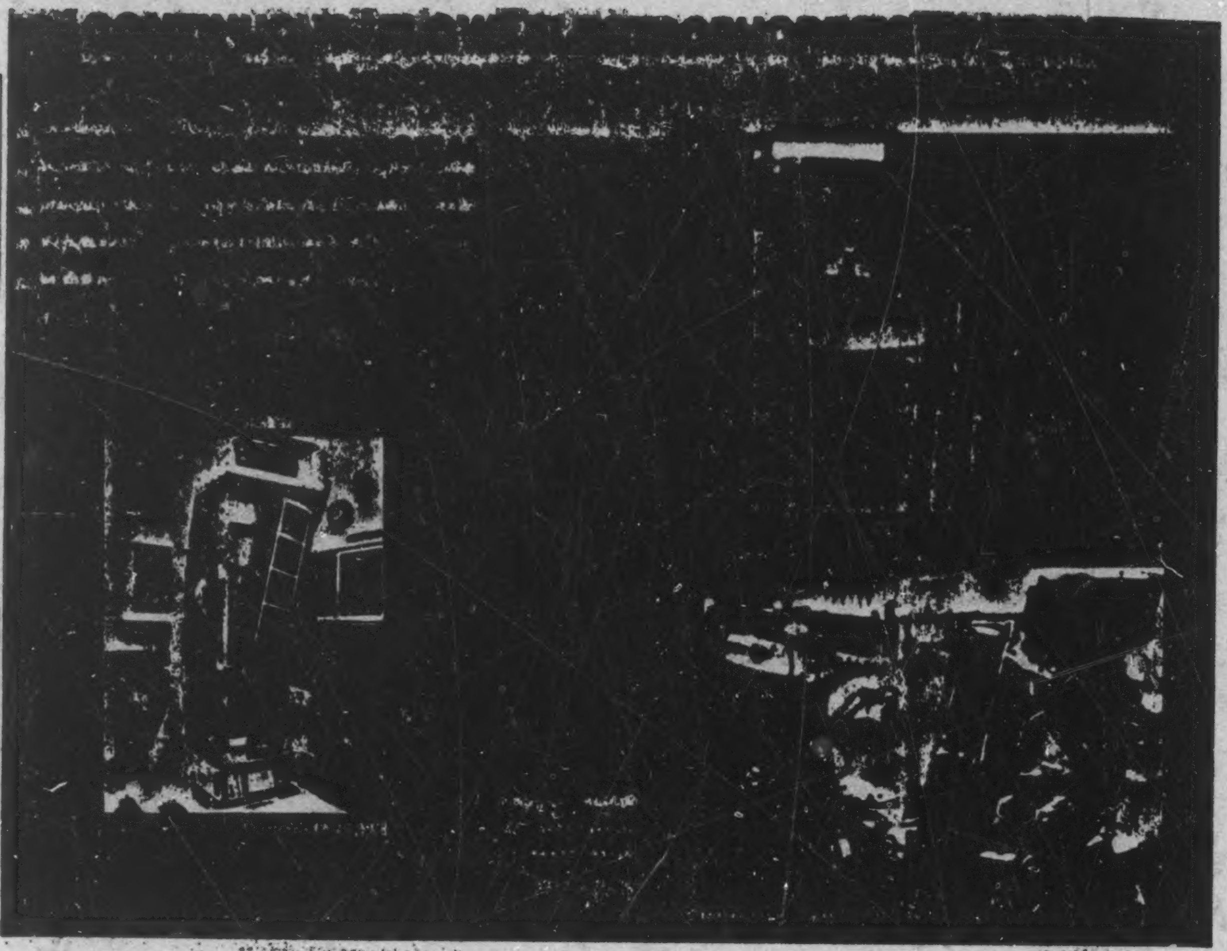


SOME RESULTS FOR GROUND BASED ZERO GRAVITY FACILITIES

- UNDERCOOLING OF 500°K FOR UP TO 30% Ge IN NOBIUM GERMANIUM (NbGe) COMPOUNDS
  - POSSIBILITY OF PRODUCING NEW PHASES IN BULK, ESPECIALLY THE SUPERCONDUCTING Nb_3Ge PHASE
- PRODUCTION OF HOLLOW ALUMINUM SPHERES
  - INTEREST OF ALCOA IN JOINT VENTURE
- PRELIMINARY RESULTS OF CAST IRON SOLIDIFICATION
  - J. DEERE INTERESTED IN SHUTTLE EXPERIMENTS
- PROOF OF CONCEPT TEST OF JPL ELECTROSTATIC POSITIONING SYSTEM
  - USE IN LEWIS RESEARCH CENTER COMBUSTION EXPERIMENTS
- PROOF OF CONCEPT TEST OF THE PULSE CALORIMETRY TECHNIQUE FOR MEASURING THE PROPERTIES OF LIQUID METALS
  - LIQUID METAL COLUMN STABLE FOR SUPERHEAT 50°K
- UNEXPLAINED LARGE VOLUME FRACTION OF DELTA FERITE PHASE IN UNDERCOOLED AUSTENITIC STAINLESS STEELS.

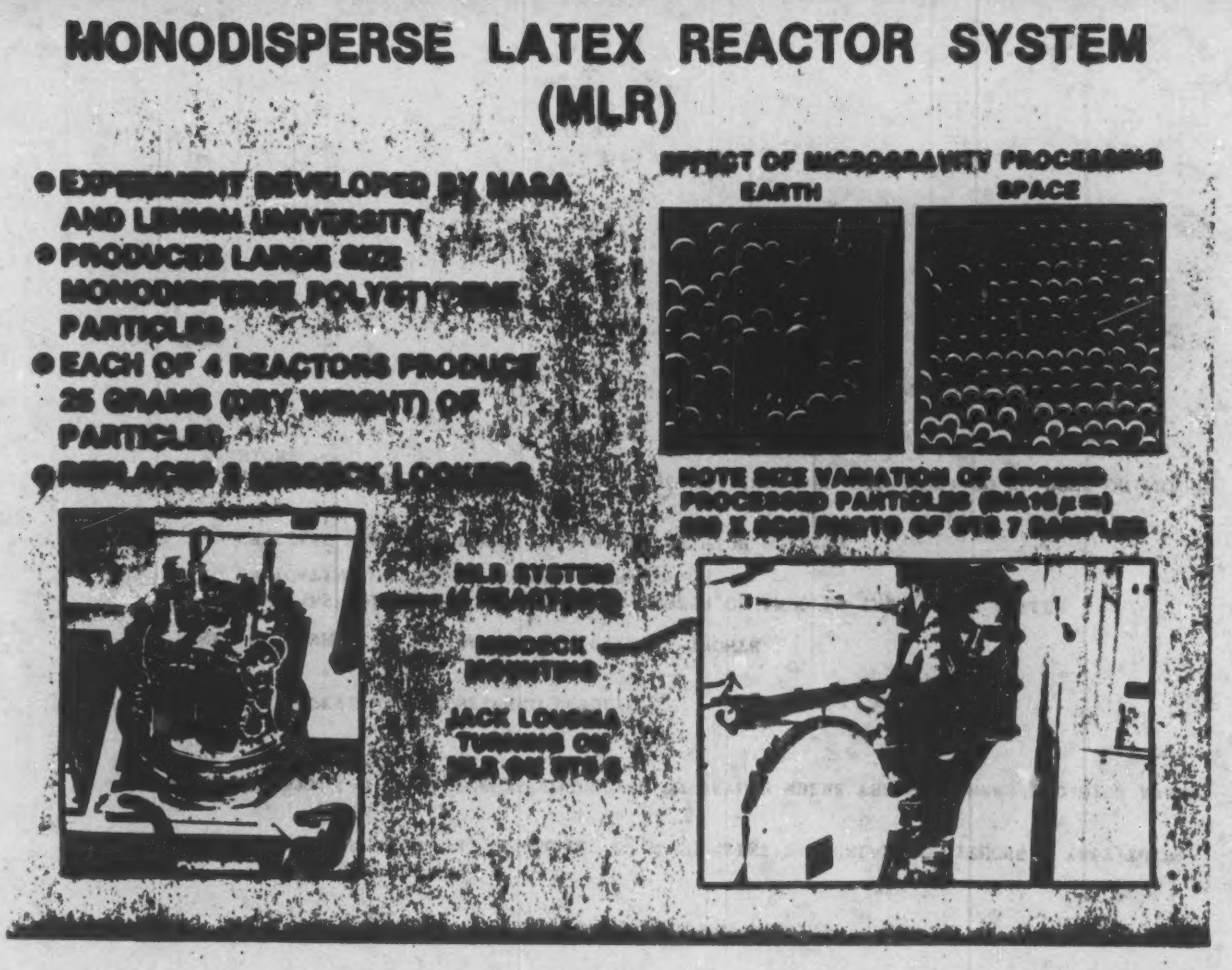
CONTINUOUS FLOW ELECTROPHORESIS SYSTEM

- o MDAC SPONSORED RESEARCH CARRIED OUT UNDER JEA
- o 5 FLIGHTS TO DATE
- o LATEST FLIGHT - PRECOMMERCIAL ENGINEERING TEST OF SYSTEM AND PRODUCTION OF PROPRIETARY HORMONE FOR TESTS
  - C. WALKER PARTICIPATED AS PAYLOAD SPECIALIST
  - 83% OF MATERIAL SEPARATED/PURIFIED
  - SYSTEM FUNCTIONED AS EXPECTED
  - CONTAMINATION APPARENTLY DESTROYED SAMPLE
  - TEST WILL HAVE TO BE REPEATED
- o NASA SPONSORED RESEARCH HAD 4 OPPORTUNITIES (EXPERIMENTS) TO USE CFES
- o PLAN ON EXTENDING NASA USE OF CFES POST JEA FOR ADDITIONAL EXPERIMENTS



MONODISPERSE LATEX PRODUCTION IN SPACE

- PRINCIPAL INVESTIGATOR, JOHN VANDERHOFF/LEHIGH UNIVERSITY
- FIVE SHUTTLE FLIGHTS TO DATE
- MONODISPERSE LATEX BEADS PRODUCED IN SPACE FOR SIZES UP TO 30u DIAMETER
- SPACE PROCESSED BEADS HIGHER QUALITY OVER GROUND FOR SIZES GREATER THAN 5u DIAMETER
- NBS EVALUATING 3u AND 30u DIAMETER TO DETERMINE SUITABILITY AS STANDARDS
- 10u DIAMETER TRANSFERRED TO NBS IN JUNE WILL GO ON SALE IN SPRING AS PART OF STANDARD REFERENCE MATERIALS PROGRAM ADMINISTERED IN CONJUNCTION WITH AMERICAN SOCIETY FOR TESTING MATERIAL



MONODISPERSE LATEX REACTOR SYSTEM
(MLR)

- EXPERIMENT DEVELOPED BY NASA AND LEHIGH UNIVERSITY
- PRODUCES LARGE SIZE MONODISPERSE POLYSTYRENE PARTICLES
- EACH OF 4 REACTORS PRODUCE 25 GRAMS (DRY WEIGHT) OF PARTICLES
- REPLACES 2 MIDDECK LOCKERS

MLR SYSTEM (4 REACTORS)

MIDDECK MOUNTING

JACK LOUSMA TURNING ON MLR ON STS 3

EFFECT OF MICROGRAVITY PROCESSING

EARTH
SPACE

NOTE SIZE VARIATION OF GROUND PROCESSED PARTICLES (DIA 10 μm)
500 X SEM PHOTO OF STS 7 SAMPLES

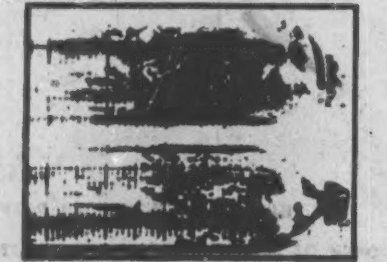
VAPOR CRYSTAL GROWTH

- PRINCIPAL INVESTIGATOR, PROFESSOR H. WIEDEMEIER/RENSSELAER POLYTECHNIC INSTITUTE
- CONTINUATION OF EXPERIMENTS CONDUCTED ON SKYLAB WHERE THE P.I. MEASURED HIGH AMOUNT OF MASS TRANSFER
- OSTA-2 EXPERIMENTS CONFIRMED RESULTS
- NEW DISCOVERY IN THE PATTERN OF CRYSTAL GROWTH
  - CRYSTALS APPEARED TO NUCLEATE IN CENTER OF AMPOULE (AWAY FROM WALLS) INDICATING HOMOGENOUS NUCLEATION
  - CRYSTALS WERE REGULARLY SHAPED AND OF HIGH QUALITY
- POSITIVE IMPLICATIONS FOR GROWTH OF HgCdTe (INFRARED DETECTOR) TO BE DONE ON FUTURE MISSIONS

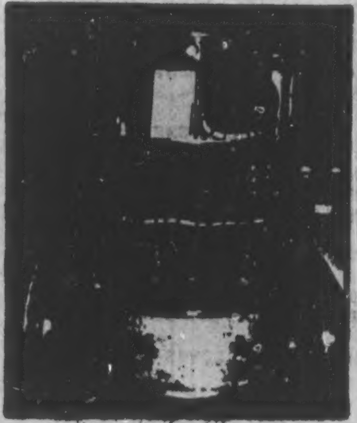
GENERAL PURPOSE ROCKET FURNACE

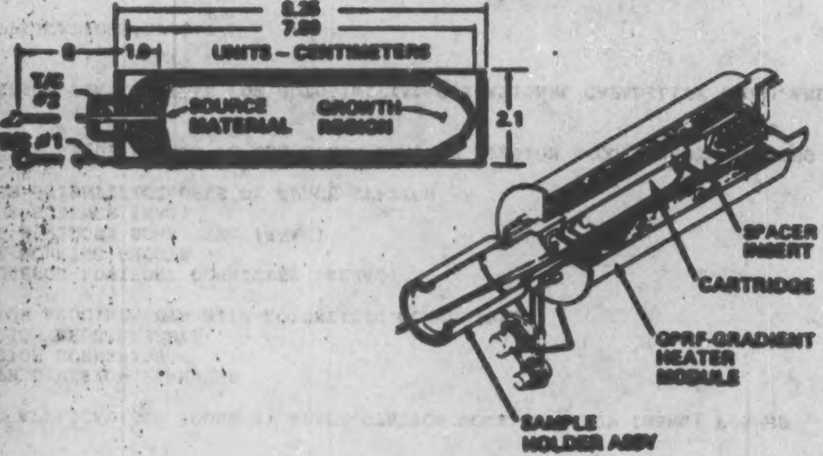
ISOTHERMAL/GRADIENT OPTIONS

TEMPERATURE	1000°C
GRADIENT	0-50°C/cm
QUENCH RATE	800°C/cm
NUMBER OF SAMPLES	3
GRADIENT CARTRIDGE	2.0 x 7.9 cm
ISOTHERMAL CARTRIDGE (NOT SHOWN)	1.2 x 2.2 cm



TOP — IN SPACE
BOTTOM — ON GROUND




8.25
7.90
0
1.9
UNITS – CENTIMETERS
T/C #2
T/C #1
SOURCE MATERIAL
GROWTH REGION
2.1
SPACER INSERT
CARTRIDGE
GPRF-GRADIENT HEATER MODULE
SAMPLE HOLDER ASSY

SPACE STATION FY 1984

- O OFFICE OF SPACE SCIENCE AND APPLICATIONS (CODE E) SPACE STATION WORKING GROUP (SSWG) FORMED
  - HOLD WEEKLY MEETINGS WITH DIVISION PLANNERS
  - DEVELOP PRELIMINARY MISSION SCENARIOS
  - DEVELOP PRELIMINARY MISSION REQUIREMENTS
  - REVIEW PRELIMINARY MISSION REQUIREMENTS WITH SCIENTIFIC COMMUNITY
    - SPACE AND EARTH SCIENCE ADVISORY COMMITTEE (SESAC)
    - PROGRAM DISCIPLINE WORKING GROUPS
    - SPACE APPLICATIONS ADVISORY COMMITTEE (SAAC)
    - NATIONAL ACADEMY OF SCIENCE (NAS)
    - SESAC TASK FORCE ON SCIENTIFICC USES OF SPACE STATION
  - PROVIDE PRELIMINARY MISSION REQUIREMENTS TO THE SPACE STATION MISSION REQUIREMENTS WORKING GROUP (MRWG)
  - DEVELOP INITIAL CODE E SPACE STATION PLAN FOR BOTH INITIAL OPERATIONAL CAPABILITY (IOC) AND BEYOND
- O MICROGRAVITY SCIENCE AND APPLICATIONS EFFORT
  - ASSIGNED MANAGEMENT RESPONSIBILITY FOR MICROGRAVITY MANNED LABORATORY BY SPACE STATION ASSOCIATE ADMINISTRATOR
  - PROVIDE PLANNER TO CODE E SSWG WHO DEVELOPS INPUTS FOR MISSION SCENARIOS; PRELIMINARY MISSION REQUIREMENTS AND THEIR REVIEW WITH THE SCIENTIFIC COMMUNITY, AND INPUT TO MRWG
  - AWARDED INTERIM CONTRACT FOR INITIAL DEVELOPMENT OF MISSION REQUIREMENTS FOR THE MICROGRAVITY AND MATERIALS PROCESSING FACILITY (MMPF)
  - RELEASED REQUEST FOR PROPOSAL FOR MMPF STUDY
  - INTERACTION WITH SCIENTIFIC COMMUNITY
    - DISCIPLINE WORKING GROUPS
    - SESAC SUMMER STUDY
    - SYMPOSIUM, ETC.
    - OTHER SCIENCE GROUPS

COMMERCIAL OPERATIONS FY 1984

O WORKING DIRECTLY WITH THE OFFICE OF COMMERCIAL PROGRAMS

- DEVELOPED AGREEMENT OF TASKS TO BE DONE BY CENTERS
- MAINTAIN PROGRAM INFORMATION FLOW TO COMMERCIAL AREA
- RESPONSIBLE FOR MANAGEMENT OF COMMERCIAL TASKS AT CENTERS

O WORK DIRECTLY WITH HEAD, SPACE STATION COMMERCIAL WORKING GROUP

O MAINTAIN RESPONSIBILITY FOR COMMERCIAL MICROGRAVITY APPLICATIONS OF THE MSAD PROGRAM

- JOINT ENDEAVOR AGREEMENT (JEA)
- TECHNICAL EXCHANGE AGREEMENT (TEA)
- INDUSTRIAL GUEST INVESTIGATOR (IGI)

O PROVIDE CENTER SCIENTIFIC AND ENGINEERING SUPPORT/ADVICE TO POTENTIAL COMMERCIAL USERS

- PHARMACEUTICAL
- ELECTRONIC MATERIALS
- AUTOMOBILE
- CHEMICAL
- METAL

O PROVIDE ACCESS TO GROUND TEST FACILITIES

O PROVIDE BROCHURES AND DATA SHEETS ON APPARATUS, GROUND TEST FACILITIES, ETC.

O DEVELOPMENT OF MICROGRAVITY MATERIALS SCIENCE LAB AT LEWIS RESEARCH CENTER FOR USE OF FLIGHT-LIKE APPARATUS BY GOVERNMENT RESEARCHERS, UNIVERSITY, AND INDUSTRY

FLIGHT EXPERIMENT PROGRAM THRU CY 1986

	PLANNED LAUNCH DATE			
	*8/83	ACTUAL	5/84	PROJECTED 11/84
o SPACELAB 1 (SL-1)				
- EUROPEAN MATERIALS SCIENCE AND TECHNOLOGY	10/83	11/83		
o 36 EUROPEAN SCIENTIFIC EXPERIMENTS				
o 1 U.S. TECHNOLOGY EXPERIMENT (TRIBOLOGICAL)				
o ACOUSTIC CONTAINERLESS EXPERIMENT SYSTEM 1 (ACES-1)	1/84	2/84		
- STUDY A LEVITATED FLUORIDE GLASS SAMPLE				
o ISOELECTRIC FOCUSING EXPERIMENT 1 (IEF-1)	1/84	2/84		
- TEST EFFECTS OF ELECTRO-OSMOSIS ON SEPARATION OF BIOLOGICAL COMPOUNDS				
o MONODISPERSE LATEX REACTOR (MLR)	1/84	2/84		
- PRODUCE LARGE DIAMETER LATEX SPHERES				
o CONTINUOUS FLOW ELECTROPHORESIS SYSTEM (CFES)	5/84	8/84	8/84	
- MDAC PAYLOAD				
o AUTOMATED DIRECTIONAL SOLIDIFICATION FURNACE 1 (ADSF-1)	5/84		8/84	5/85
- EUTECTIC GROWTH OF MANGANESE BISMUTH				
o MATERIALS SCIENCE LABORATORY 1 (MSL-1)	5/84		11/84	10/85
- LIQUID PHASE MISCIBILITY GAP MATERIALS				
- VAPOR GROWTH OF ALLOY TYPE SEMICONDUCTOR CRYSTALS				
- CONTAINERLESS PROCESSING OF GLASS FORMING MELTS				
- DIFFUSION COEFFICIENT OF LEAD ZINC				
- DIRECTIONAL SOLIDIFICATION OF LEAD TIN TELLURIDE				
o ISOELECTRIC FOCUSING EXPERIMENT 2 (IEF-2)	8/84		8/84	5/85
- ISOELECTRIC FOCUSING PHENOMENA				
o CONTINUOUS FLOW ELECTROPHORESIS SYSTEM (CFES)	8/84		11/84	3/85
- MDAC PAYLOAD				

* NO MIDDECKS SCHEDULED BEYOND FEBRUARY 1985 IN STS AUGUST 1983 MANIFEST

FLIGHT EXPERIMENT PROGRAM THRU CY 1986

	LAUNCH DATE	
	5/84	PROJECTED 11/84
O DIFFUSIVE MIXING OF ORGANIC SOLUTIONS 1 (DMOS-1) - 3M PAYLOAD		11/84

FLIGHT EXPERIMENT PROGRAM THRU CY 1986

	PLANNED LAUNCH DATE			
	8/83	ACTUAL	**5/84	***PROJECTED 11/84
O AGGREGRATION OF RED BLOOD CELLS 1 (ARC-1) - AUSTRALIAN EXPERIMENT	8/84		11/84	1/85
O MATERIALS SCIENCE LABORATORY 2 (MSL-2)	10/84		8/85	8/85
- SOLIDIFICATION OF COBALT SAMARIUM - UNDERCOOLING OF NICKEL TIN - TWO PHASE DROP BEHAVIOR				
O SPACELAB 3 (SL-3)	11/84		1/85	4/85
- SOLUTION GROWTH OF CRYSTALS IN ZERO GRAVITY - MERCURIC IODIDE CRYSTAL GROWTH - DYNAMICS OF ROTATING AND OSCILLATING FREE DROPS				
O PROJECTED FOR CY 85				
- AUTOMATED DIRECTIONAL SOLIDIFICATION FURNACE 2 (ADSF-2)	2/85		3/85	
- SPACELAB D-1 (SL-D1)	6/85		10/85	10/85
O FLY MSL-1 EXPERIMENTS AS PART OF GERMAN MISSION				
- ELECTROPHORESIS OPERATIONS IN SPACE 1 (EOS-1)	7/85		7/85	11/85
O MDAC PAYLOAD				
- MATERIALS SCIENCE LABORATORY 3 (MSL-3)	11/85		11/85	12/85
O SOLIDIFICATION OF COBALT SAMARIUM O UNDERCOOLING OF NICKEL TIN O TWO PHASE DROP BEHAVIOR				

** NO MIDDECKS SCHEDULED BEYOND JULY 1985 IN STS MAY 1984 MANIFEST
*** NO MIDDECKS SCHEDULED BEYOND MAY 1985 IN STS PROJECTED NOVEMBER 1984 MANIFEST

FLIGHT EXPERIMENT PROGRAM THRU CY 1986

	PLANNED LAUNCH DATE			
	8/83	ACTUAL	5/84	PROJECTED 11/84
PROJECTED FOR CY 1986				
O ELECTROPHORESIS OPERATIONS IN SPACE 2 (EOS-2)	1/86		7/86	6/86
O MATERIALS SCIENCE LABORATORY 4 (MSL-4)	7/86		7/86	7/86
O MATERIALS SCIENCE LABORATORY 5 (MSL-5)			10/86	10/86
O MONODISPERSE LATEX REACTOR 6 (MLR-6)			8/84	5/85
- PRODUCE LATEX SPHERES GREATER THAN 30 MICROMETERS				
O MONODISPERSE LATEX REACTOR 7 (MLR-7)			2/85	
- PRODUCE LATEX SPHERES 50 MICROMETERS OR LARGER				
O ACOUSTIC CONTAINERLESS EXPERIMENT SYSTEM 2 (ACES-2)			3/85	
O MONODISPERSE LATEX REACTOR 8 (MLR-8)			5/85	
- PRODUCE 100 MICROMETER DIAMETER LATEX SPHERES				
O AGGREGATION OF RED BLOOD CELLS 2 (ARC-2)			7/85	
- AUSTRALIAN EXPERIMENT				

SPACELAB AND CARGO BAY EXPERIMENTS

MEA-1 (JUNE 1983)
- 3 INVESTIGATIONS SELECTED 1977

SPACELAB III (APRIL 1985)
- 2 INVESTIGATIONS SELECTED 1977

MSL-2 (AUGUST 1985)
- 2 INVESTIGATIONS SELECTED 1977
- 1 INVESTIGATION SELECTED 1983

MSL-1 (OCTOBER 1985)
- 4 INVESTIGATIONS SELECTED 1977
- 1 EXTENSION OF ROCKET EXPERIMENT SELECTED 1976

MSL-3 (DECEMBER 1985)
- 2 INVESTIGATIONS SELECTED 1977
- 1 INVESTIGATION SELECTED 1983

MSL-4 (JULY 1986)
- 2 INVESTIGATIONS SELECTED 1977
- 1 EXTENSION OF ROCKET EXPERIMENT SELECTED 1976
- 1 INVESTIGATION SELECTED 1984

MSL-5 (OCTOBER 1986)
- 1 EXTENSION OF EXPERIMENT SELECTED 1976
- 2 INVESTIGATIONS SELECTED 1977
- 1 INVESTIGATION SELECTED 1983
- 1 NEW SLOT

MSL-6 (JANUARY 1987)
- 1 INVESTIGATION SELECTED 1977
- 1 EXTENSION OF ROCKET EXPERIMENT SELECTED 1976
- 1 INVESTIGATION SELECTED 1984
- 1 NEW SLOT

SPACELAB AND CARGO BAY EXPERIMENTS

MSL-7 (MARCH 1987)
- 2 INVESTIGATIONS SELECTED 1977
- 1 INVESTIGATION SELECTED 1983
- 2 NEW SLOTS

MSL-8 (MAY 1987)
- 1 INVESTIGATION SELECTED 1977
- 3 NEW SLOTS

MSL-9 (SEPTEMBER 1987)
- 2 INVESTIGATIONS SELECTED 1977
- 3 NEW SLOTS
- 1 INVESTIGATION SELECTED 1983

MICROGRAVITY FLIGHT INSTRUMENTS

APPARATUS	COMPLETED	PROJECTED COMPLETION
AUTOMATED DIRECTIONAL SOLIDIFICATION FURNACE (ADSF)	MAR 84	
AUTOMATED DIRECTIONAL SOLIDIFICATION FURNACE-II (ADSF-II)		JUN 85
ISOELECTRIC FOCUSING EXPERIMENT SYSTEM (IEF)	FEB 84	
ACOUSTIC CONTAINERLESS EXPERIMENTS SYSTEM (ACES)	FEB 84	
CONTINUOUS FLOW ELECTROPHORESIS SYSTEM (CFES)	1982	
MONODISPERSE LATEX REACTOR (MLR)	MAR 82	
DROPLET COMBUSTION EXPERIMENT SYSTEM (DCE)		APR 87
PARTICLE CLOUD COMBUSTION EXPERIMENT SYSTEM (PCCE)		MAR 87
SOLID SURFACE COMBUSTION EXPERIMENT SYSTEM (SSCE)		NOV 85
GENERAL PURPOSE FURNACE-I (ISOTHERMAL) (GPRF-I)	OCT 82	
GENERAL PURPOSE FURNACE-G (GRADIENT) (GPRF-G)	OCT 82	
GENERAL PURPOSE FURNACE-1 (GRADIENT) (GPRF-1)	AUG 84	
GENERAL PURPOSE FURNACE-2 (GRADIENT) (GPRF-2)	NOV 84	
SINGLE AXIS ACOUSTIC LEVITATOR (SAAL)	JUN 84	
SINGLE AXIS ACOUSTIC LEVITATOR-II (SAAL-II)		JUN 87
THREE-AXIS ACOUSTIC LEVITATOR (3AAL)		APR 85
ADVANCED AUTOMATED DIRECTIONAL SOLIDIFICATION FURNACE (AADSF)		DEC 86
ELECTROMAGNETIC LEVITATOR (EML)	OCT 84	

MICROGRAVITY FLIGHT INSTRUMENTS

APPARATUS	COMPLETED	PROJECTED COMPLETION
FLUIDS EXPERIMENT SYSTEM (FES)	NOV 83	
VAPOR CRYSTAL GROWTH SYSTEM (VCGS)	NOV 83	
AGGREGATION OF RED BLOOD CELLS SYSTEM (ARC)(CO-OP)	AUG 84	
MEPHISTO (CO-OP)		JUN 85
BLOOD STORAGE SYSTEM		JAN 86
DROP DYNAMIC MODULE (DDM)	NOV 83	
SUPERFLUID HELIUM SYSTEM	MAR 84	
LAMBDA POINT EXPERIMENT SYSTEM		1988

APPENDIX 6

W.W. HANSEN LABORATORIES OF PHYSICS
STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305-2184

Edward L. Ginzton Laboratory
High Energy Physics Laboratory

Telephone (415) 497- 1389

March 7, 1985

The Honorable Bill Nelson
Room 307
Common House Office Building
Washington D.C. 20515

Dear Congressman Nelson:

In connection with Gravity Probe B I would like to request that the enclosed document by Bradford W. Parkinson be included as written testimony to the Space Science and Applications subcommittee hearings on the NASA budget for FY 1986.

Sincerely,

C.W.F. Everitt

Enclosures

Testimony of Professor Bradford W. Parkinson, Stanford University, Project Manager for Gravity Probe B

Gravity Probe B as a Management Experiment: New Approaches to Cost Reduction and Cost Control in NASA Programs

Gravity Probe B is an extremely important space experiment to test the General Theory of Relativity. It is the first time space has been used to test a fundamental theory of physics. It has received the endorsement of Nobel prize winners and the Space Sciences Board. However, the reason for our testimony is to point out a second important experiment associated with GP-B - the "Management Experiment".

At a time of tight budgets the "Management Experiment" deserves close attention. Properly executed it can lead to significant cost savings. We have already applied it with NASA support to lower the cost of the Gravity Probe B spacecraft by 40% with substantial reductions in risk but no loss in science. We believe that if we are allowed to carry out the management experiment as proposed it can serve as a model for the efficient use of resources in future small to medium sized NASA programs.

THE HYPOTEHSIS: University/Aerospace projects can be effectively "Managed by Objectives" with a small, highly-competent and motivated core group at the University, and lead to:

1) a more efficient use of R & D dollars
2) faster development of complex payloads, and
3) more predictable costs with less "surprises".

BACKGROUND: The management experiment is based partly on ideas gained from previous examples of streamlined and highly developed technical efforts such as Lockheed's "Skunkworks" and the Air Force Special Projects. Within my personal experience is the NAVSTAR Global Positioning System, for which we invented (i.e., no phase B), designed, built, tested and supported the launch of six satellites of medium size and complexity for $120M. The first launch was approximately three and one-half years after contract go-ahead. The satellite portion of this effort was managed by a four person team with about four tehnical helpers from the Aerospace corporation. An example of an effective low cost University/Aerospace project supported by NASA is the Solar Maximum Explorer managed by JPL through the University of Colorado and brought in on schedule and under budget.

The key to success in all these programs was the selection and activities of highly competent people, and making them fully accountable for well defined pieces of the effort. This is what we are doing on Gravity Probe B. Ancillary to that was a reduction in reporting requirements. With a properly managed team such a reduction, far from reducing accountability, actaully increases it. Responsibility is put where it belongs, on people not on paper. For GP-B NASA has boldly reduced the reporting requirements by 60% from what they would in a conventional program of comparable size.

MANAGEMENT BY OBJECTIVES: We have explicitly stated nine core requirements for our test of Einstein's theory. Derived from these, our proposal to NASA stated 25 system level requirements. Similar to these clearly stated performance requirements, we have stated top level cost and schedule objectives. The accountable team members will be managing to these objectives in cost, schedule and performance.

We have also developed a tailored system of loose/tight controls for the reporting process. This means that tight controls are only applied on technical performance at the subsystem level, thereby allowing the accountable individual the freedom to internally manage his subsystem development. Detailed planning beyond fine-grained present knowledge is avoided since that only leads to fruitless effort. On the other hand we will develop reasonably detailed plans on the basis of a six month "rolling wave".

SMALL HIGHLY MOTIVATED GROUP: The management group at Stanford will consist of five persons, carefully selected for their background, competence and energy levels. The decision by NASA to reduce the reporting requirements, will allow this group to concentrate on managing Stanford and our Lockheed subcontractor.

We have created integrated teams of Stanford and Lockheed personnel to review requirements, control interfaces, and approve specifications. Depending on the program needs, the chairmen of certain of these groups are from Lockheed, although Stanford maintains ultimate approval authority. In the formal charters, we have made clear that all members of each team are encouraged to contribute and expected to accept action items. Thus everyone is part of the solution rather than any being part of the problem. To ensure that Lockheed keeps the best team on the job, fifty percent of the award fee is given for the assignment and retention of key people.

MOTIVATED CORE GROUP: Motivatation is the most important and the most intangible aspect of our management experiment. We have worked hard to give eachkey member his accountable area. At the same time both Lockheed and Stanford have fostered a total team spirit and avoided the "we-they" syndrome. Our approach to reporting encourages candor and early exposure of potential problems. Weekly integrated team meetings are held at the program level. An electronic mail system shortens the lines of communication, making everyone feel that they are essential to the effort. By moving towards a paperless process, our efficiency should increase,which is also a strong morale builder.

PROGRESS TO DATE: We have applied the method already to a radical redesign of the GP-B spacecraft, leading to a halving of the weight and power and a corresponding reduction in cost and risk. As an example of the efficiency of the system we were able in subcontractor selection to meet all dates exactly and go from RFP to "on contract" in eleven weeks (about one-third of the normal elapsed time in NASA programs). The effectiveness of the Stanford/Lockheed cooperation was demonstrated with the creation of a four value combined proposal to NASA in eighteen days.

CONCLUSION: One of the great dangers in difficult times is "learned helplessness" in the face of bureaucracy. The best answer is through successful counter-examples. The circumstances are right for Gravity Probe B to provide such a counter-example - if it is supported at an adequate (not excessive) level. The original $12M identified by NASA in its FY 1986 in its submission to the OMB is the appropriate level to start the Management Experiment on the right footing, as is shown in our detailed planning documents.

APPENDIX 7

STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305

OFFICE OF THE PRESIDENT

RECEIVED
[illegible]
COMMITTEE ON SCIENCE
AND TECHNOLOGY

March 19, 1985

The Honorable Don Fuqua
Chairman, House Committee on
Science and Technology
2269 Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Chairman:

As the Chairman of the House Committee on Science and Technology, I know you are aware of the fact that the NASA research budget for FY 1986 would support no "new starts", a policy that, if agreed to by the Congress, would send a very negative message to the space science community. It would have serious and unfortunate ramifications for the future success of our space program.

I am very concerned about OMB's decision to eliminate funding for all new starts in NASA's FY 1986 budget and the fallout that decision will have on two ongoing projects -- TOPEX and Gravity Probe B.

Stanford has been working for over twenty years on the Gravity Probe B, since 1960 when the late Leonard Schiff, then Chairman of our Physics Department, suggested the possibility of a test of Einstein's General Theory of Relativity based on orbiting gyroscopes. For the past eighteen years, NASA has been supporting the research on the Gravity Probe B. This long period of research has not only laid the basis for a new and uniquely important test of Relativity, it has pioneered a whole new technology -- e.g., drag-free satellites, long hold-time helium dewars for space, and a gyroscope six orders of magnitude better than the best inertial navigation gyroscopes.

We are now ready to move ahead with the engineering development of the Gravity Probe B project using what we call the "second GP-B experiment": a pioneering new method of managing university/aerospace programs with the aim of developing a flight experiment more quickly, with lower cost and less chance of "surprises." In response to an RFP from NASA and with NASA's active support and encouragement, we developed and submitted a proposal for this second stage, which has been peer reviewed and approved and for which we have the final contract from NASA in hand. We have assembled a small, high quality team made up of engineers and scientists from our faculty and academic staff and from our aerospace subcontractor, Lockheed.

NASA's decision to reclassify the Gravity Probe B as a "new start" and OMB's subsequent decision to cut out new starts have forced the agency to reduce its commitment of funding to the project in FY 1986 by 50% -- from $12 million to $6 million. At the reduced funding level, once Stanford's irreducible expenses are met, we will be able to provide less than $1 million to support the Lockheed portion of the team. The effect will be to amputate a critical member of the university/aerospace team and move us back from a flight development to a research mode.

I understand that the sole reason the Gravity Probe B project is not being continued at the projected level is budgetary. Small as the $6 million differential is at the national level, from our point of view -- and from the larger point of view of demonstrating that there are indeed better and cheaper ways of doing NASA business -- the loss is devastating. I urge you to support sufficient funding to permit this important ongoing project to proceed at something close to the original commitment of funds.

Sincerely,

Donald Kennedy

APPENDIX 8

MMINC 2000
THIRD MILLENNIUM, INC.

918 F Street, N.W., Suite 601 Washington, D.C. 20004 202-347-5060
3290 Cache Peak Drive, Reno, Nevada 89512 702-673-6066

IN SUPPORT OF RESEARCH AND DEVELOPMENT —
TAX CODE MODIFICATIONS TO ENCOURAGE RISKTAKING AND R&D

RESPECTFULLY SUBMITTED BY THIRD MILLENNIUM, INC. TO THE

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

It is no fluke that ingenuity is tagged as a specifically 'American' trait. The U.S. is known worldwide for its technical expertise; here in the states, both the public and private sectors view Yankee inventiveness as the key to economic prosperity.

Yet taking breakthroughs from perception to production has become increasingly difficult. Above and beyond the usual marketing and management risks start-up firms face severe disadvantages under the present tax code. Individual entrepreneurs are inadvertently penalized for the risk-taking that should, in fact, be lauded. New companies, striving to bring advances to market, are undercut in their efforts to secure R&D dollars.

Third Millennium, Inc. of Reno, Nevada respectfully offers the following insight into the present tax code and its effect on individual risk taking and small business R&D.

CLEARING THE PATH FOR INDIVIDUAL RISK TAKING

Development-stage companies, as defined by the Financial Accounting Standards Board (FASB), are firms in the first stages of formation. These firms do not post profits; yet, if they survive, these same companies will likely create the majority of new jobs. Unfortunately, the present tax code dramatically undermines the efforts of such companies by penalizing the individuals who personally take the risk of getting them going.

VOLUNTEERS

Volunteer labor is essential to start-up firms. From legal help to engineering and typing services, many people contribute time to companies they believe in — often getting stock in return for their work. These people stand to benefit from their work should the company succeed. The risk is great, however, that the company will fail and that they will receive nothing for their efforts.

At present, stock received for volunteer labor is taxed as if it were income. The company may be without assets and the stock received worth nothing; yet the volunteer is taxed based upon his earning power elsewhere. For example, an accountant who normally charges $50 an hour may receive 1000 shares for twenty hours of work on a business plan. This luckless volunteer will end up owing taxes on an additional $1000 in income he "received" in the form of stock. The reality is that he has earned no cash to pay the taxes with and, more likely than not, the stock is still worthless and/or cannot be sold to meet the debt.

Potential solution To address this problem, Third Millennium suggests that volunteers in development-stage companies be allowed to accept stock for services rendered without tax penalty. A development-stage company, as defined by Statement of Financial Accounting Standards No. 7 is a firm "devoting substantially all of its efforts to establishing a new business" and where "either of the following conditions exists:

1) Planned principal operations have not commenced.
2) Planned principal operations have commenced, but there has been no significant revenue therefrom."

Third Millennium respectfully requests that Congress enact legislation clarifying the tax code such that volunteers in development-stage corporations not be taxed on the stock they receive in return for their services:

A: Until the stock is sold, the portion sold to be taxed with the price determining the value.
B: Until the company pays dividends on the stock.
C: Until the company ceases to be a development stage company as defined by FASB 7.

With this approach, volunteers will not be penalized for donating their time to a young firm. Since they still receive no value for their labor until the company actually succeeds, the incentive for extra effort remains. The only cost to the public is a loss of interest income incurred when the tax dollars from the stock are delayed. This should be more than made up later when the individual is paying tax on stock made more valuable because his firm has succeeded — a firm that is generating new tax dollars as well.

INDIVIDUAL INVESTORS AND START-UP COMPANIES

Like volunteers, investors buying into a new firm back their faith with their resources; running the same risk that their resources will be completely lost if the company fails. They are also at a similar disadvantage with respect to the tax code, since discounts on the debentures of development stage companies are taxed as interest.

For example, a start-up company offers $10,000 bonds to finance its project and discounts those bonds 40% because of the risk involved. An investor buys a bond paying $6,000 for the promise of $10,000 later. His taxes will show $4,000 in imputed interest. Though the company may fail and the investor never see that $4,000, he must still pay taxes on it. It is hardly surprising that new companies find investors becoming rather scarce.

Potential solution Third Millennium respectfully requests that Congress enact legislation modifying the tax code such that the discount on debentures from development stage firms not be taxed as imputed interest:

A: Until the debenture is paid.
B: Until the company ceases to be a development-stage company.
C: At all, if the debenture is defaulted upon.

These measures should not cost the federal treasury revenue dollars, for they merely delay tax payments until the new companies are on their feet. In the end, there should be an increase in revenue since this boost to new companies increases their chances of survival and growth into vital, tax-paying concerns.

GIVING A BOOST TO SMALL-COMPANY INNOVATION

In the scramble to obtain financing there are many areas in which a company must compete. Of these areas -- risk, rate of return, market strength -- one of the most crucial is tax position. Business-tax incentives are so powerful they alter the rate of return. Tax position will make or break a project's financing and no group seeking capital can afford to ignore it.

Unfortunately, present incentives are often inaccessible to the firms most known for innovation -- small companies. Small, cash-hungry start-ups, do not have the income, and therefore the taxes, against which to post tax credits and deductions. Development-stage firms (as defined above) have little or no income or taxes at all.

The following example illustrates the tremendous negative impact this situation has on start-up firms. It shows how inaccessible tax incentives force a start-up company to spend $100,000 on the same project a firm with tax breaks can complete for only $41,500.

Assumptions

1) The new firm, NEWSTART INC., undertakes an R&D project that will cost $100,000 to complete -- all of the money to be spent this year.
2) The established firm, called OLDLINE INC. undertakes exactly the same project for the same $100,000 — also to be spent this year.
3) Being a new firm with only its one project, NEWSTART INC. has no income.
4) OLDLINE INC. has income for the year of $200,000 from other non-R&D sources.
5) This is the first R&D project for each firm.

OLDLINE INC. — TAX INCENTIVES CUT PROJECT COST

OLDLINE INC. made $200,000 this year from other sources. It can deduct all of the R&D it does as an expense, reducing its taxable income to only $100,000.

INCOME	$200,000
R&D	-$100,000
TAXABLE INCOME	$100,000

Tax due on income of $200,000 is $71,750.
Tax due on income of $100,000 is $27,750.
Tax savings due to R&D expenses is $46,000.

TAX SAVINGS	$ 46,000

OLDLINE also gets a tax credit. Since this is their first R&D project, half of the research funds spent will be eligible for the credit. Of that half (a total of $50,000) they get to take one quarter as a tax credit. One quarter of $50,000 is $12,500. For the research done that year 12.5% of the cost is effectively saved as a result of the tax credit.

TAX CREDIT	$ 12,500

Adding the tax credit to the tax savings it becomes apparent why established firms have such an advantage. They have saved $58,500 on income tax.

TAX SAVINGS	$ 46,000
TAX CREDIT	$ 12,500
TOTAL TAX SAVINGS	$ 58,500

Subtracting the total tax savings from the cost of the project cost shows that OLDLINE INC.'S actual cost to do the project is only $41,500.

PROJECT COST	$100,000
TAX SAVINGS	$ 58,500
ACTUAL PROJECT COST FOR OLDLINE INC.	$ 41,500

NEWSTART INC. — INACCESSIBLE TAX INCENTIVES BECOME A DISINCENTIVE

NEWSTART INC. is in the development stage and is without income.	INCOME	- 0 -
NEWSTART does $100,000 of research. It will expense R&D and show a $100,000 loss.	R&D	$100,000
Since NEWSTART has no income, it has no income taxes and does not receive any current tax savings.	TAX SAVINGS	- 0 -
Since there is no tax against which to take a credit there can be no tax credits taken this year either.	TAX CREDIT	- 0 -
NEWSTART pays the same for the project but receives nothing back in the form of tax breaks.	R&D COST TAX SAVINGS TAX CREDIT	$100,000 - 0 - - 0 -
	ACTUAL PROJECT COST FOR FOR NEWSTART INC.	$100,000

Obviously start-up firms are at a severe disadvantage. In that critical first year, NEWSTART must actually expend $100,000 to do its research -- whereas OLDLINE expends only $41,500. NEWSTART can apply to get its tax credits and deductions later when it has income but that will be some time down the line. Like all new firms, NEWSTART needs the money up front when the bills are due and the outcome uncertain. If the company fails it will never receive its tax breaks -- breaks that could have helped it survive in the first place. When the company finally does get its tax dollars back, the money is worth considerably less. Like a loan given out with no interest, the money earns nothing for NEWSTART in the interim. Over a five year period the $58,500 in tax savings could have generated $58,500 in interest income alone (five years at 15% per year compounded annually.)

In actuality the problem is far worse. Risk capital is likely to cost a small firm 30% to 60% per year. NEWSTART must secure the entire $100,000 for its project rather than only $41,500. If NEWSTART must pay its backers the equivalent of 60% per year on $100,000, at the end of five years, the company will be obligated for over $1 million.

THE IMPACT OF INACCESSIBLE R&D INCENTIVES ON RAISING CAPITAL

Because small firms and start-ups end up spending more for the same results they are placed in greater peril of failure. The real pinch comes, however, when young companies compete for investment dollars. In the above example, the inability to use tax incentives could result in as much as a twelve-fold increase in effective costs for the start-up company relative to a larger firm on exactly the same project. It is not hard to imagine what this does to rates of return.

Under these conditions it is almost impossible for start-ups to finance R&D. One method used to overcome this problem is the R&D limited partnership. As in any partnership, the profits and losses are divided among partners who report it as personal income. NEWSTART's tax deductions on $100,000 of R&D would be used to off-set personal taxes for the partners. While indirect, it is a method whereby some of the tax breaks can be taken up-front when the company is still trying to pay the rent.

But limited partnerships do not totally solve the problem. They are specifically excluded from taking R&D tax credits until the partnership itself posts income. Thus, with respect to the credit, they are still at a significant disadvantage relative to established firms with income.

The limited partnership is also a difficult vehicle to set up. The laws related to its tax status are highly ambiguous and firms must have legal/accounting help to assure the partnership's tax status. The expense of hiring such help effectively excludes many small firms from using limited partnerships. Moreover, limited partnerships are in a sufficiently gray area that, even with the best advice, they can lose their tax advantages unexpectedly. Knowing this, investors demand even higher returns, squeezing little firms still further.

All in all, the present tax code puts start-ups and small firms in a far worse position than if there were no tax incentives at all.

R&D DEBENTURES -- THE POTENTIAL SOLUTION

To address this problem and encourage small/new R&D firms, Third Millennium Inc. proposes that Congress pass legislation defining the tax status of R&D debentures/bonds. Such legislation, to be truly effective, should include the following:

1) Purchasers of R&D debentures/bonds would be able to use the R&D tax credits and R&D deductions instead of the company.
2) R&D debentures/bonds would be tradable.
3) The provisions for setting up such debentures/bonds should be simple enough that small companies can afford to use them as a method of raising capital.
4) The tax status should be made clear and unambiguous so that the value of the debentures is never in question.
5) The use of R&D debentures and bonds would be available to all companies -- new and established.

NEWSTART's problem is not that it is ineligible for R&D tax incentives -- only that it can't use them. Through R&D debentures, NEWSTART could take the $58,500 that is otherwise inaccessible and pass it directly to its investors who, in turn, apply it to their own personal taxes.

This approach does not increase the total amount of revenue dollars committed to tax incentives. Companies do not take again the tax breaks they have passed on; the tax incentives are merely shifted in time so that they can be utilized in the beginning when start-up companies need the most help. The only revenue loss is in interest on the tax revenue -- this should be more than made up by the direct tax revenue from an increased number of healthy, new companies.

Giving investors part of their return in taxes in the near term makes debentures much more attractive -- a new firm may be able to get capital at 15% or 20% instead of 30% to 60% or more. For long-term investment this difference is essential. At the end of five years, at 45%, NEWSTART would owe $6,410 on a $1,000 bond. At 17.5% the company would only owe $2,240 on same bond. At high rates, even the most promising project cannot make enough money to pay back investors if the project lasts more than a year or so. The result is the lack of long term R&D that has been characteristic in the United States over the last ten to twenty years.

The implications of taking approach are enormous. New firms will be on equal footing with established firms when it comes to raising money for projects. They will be in a less risky position and able to offer better rates of return as well as receive them. Nor are large, established firms put at a disadvantage by R&D debentures. There is no reason that they cannot issue debentures as well -- or bonds backed with assets. Such a method could potentially help industry counteract the effect of foreign subsidies. It is possible, for example, that such a source of cheaper capital would have helped Boeing and McDonnell Douglas compete with the subsidized, European A-300 airbus.

Individual investors also benefit. R&D partnerships are so expense to set up that the minimum investment must be high to make it worthwhile. With proper legislative provisions, R&D debentures should be relatively easy to set up, enabling lower minimum investments. By making the debentures tradable it becomes easier for small investors -- who can not afford the risk of having large chunks of money frozen over long periods -- to become part of the investment community. Money may well shift from less desirable tax shelters to more productive R&D efforts. Ultimately, the total amount of money tagged specifically for R&D projects should increase dramatically.

This expansion of funds will eventually create more jobs -- in some cases new industries. Lower-cost capital should encourage long term R&D projects. The intense activity would help the U.S. maintain its technological leadership and tip the trade balance to a more favorable slant. Most importantly, all of this activity will take place under the guidance of America's greatest asset -- the free market system. The responsibility for finding opportunities, creating products and achieving success will be in the hands of legions of ingenious Yankees, each of whom guides his own success or failure.

INCREASED R&D WITHOUT INCREASED GOVERNMENT PARTICIPATION

In the past when U.S. technical strength was questioned, and the clamor rose for more R&D, the town criers called for more government loans, more government R&D and more government sympathy. In some ways the problems of private sector were correctly stated. Big industry leans to more lucrative projects rather than risky R&D. Start-up businesses, willing to take the risks, can't get their hands on the necessary capital.

For start-ups, no little part of the financing problem lies in the tax code. Their volunteer staffs are taxed on their unpaid efforts; their investors are taxed on income they have not -- might not -- receive, and the inaccessibility of tax 'incentives' creates a nearly insurmountable disincentive for development.

The simplest and, perhaps, fairest way to deal with R&D disincentives is to eliminate R&D tax provisions altogether. Such an approach would put all players on equal footing and eliminate the stifling complexity of the tax code. This is far preferable than the present system that favors established industry vs start-ups and -- to some extent -- large business vs small business.

More preferable, however, would be a level playing field that still encouraged R&D. Such a leveling of opportunities must include a vehicle that is sufficiently simple and unambiguous that small, new organizations can take advantage of it without huge legal and accounting fees. R&D debentures/bonds are such a vehicle. With R&D debentures, start-ups and even Fortune 500 firms can get the assist R&D incentives were intended to give. Moreover, R&D debentures should open a totally new source of research funds by making it possible for small investors to become part of the financial community.

By passing tax code changes with respect to R&D debentures, volunteers and investors, Congress would give a much needed leg-up to start-ups and small business -- the portion of the private sector recognized as the hotbed for technological breakthroughs. In passing such legislation Congress would not demand more of an already overstrained budget or put other parts of the private sector at a disadvantage. Congress would be taking direct measures to generate stronger industries, new products and a more favorable trade balance. It would be difficult indeed to find a more effective and efficient way to support that world famous American ingenuity and the future it guarantees.

APPENDIX 9

Rec. 1.-17/18/85

NASA
National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

JAN 15 1985

Honorable Don Fuqua
Chairman
Committee on Science and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

The enclosed report, "The Selection of Support Platforms for Payloads" is submitted in response to the Committee request contained in the FY 1985 NASA House Authorization Report 98-629.

This report provides background information on carrier types and addresses the procedures for selection of carriers by non-NASA users, NASA Science and Applications payloads, and NASA technology missions. Advantages and disadvantages of carrier types are provided, and payload requirements are matrixed against carrier capabilities. A top-level listing of factors which must be considered in carrier selection has been developed, but it is impracticable to develop a detailed set of guidelines.

If further information is desired, we would be pleased to respond.

Sincerely,

James M. Beggs

James M. Beggs
Administrator

Enclosures

cc:
Honorable Harold L. Volkmer
Honorable Manuel Lujan, Jr.

SELECTION OF SUPPORT
PLATFORMS FOR PAYLOADS

January 1, 1985

I. INTRODUCTION

The House of Representatives, Science and Technology Committee, Space Science and Applications Subcommittee in its FY 1985 House Authorization Report 98-629, March 29, 1984, has directed NASA to develop selection criteria for each available carrier type (i.e., freeflyer, unmanned platform, spacelab, and space station). The specific direction provided by the subcommitte is as follows:

> "Expanded utilization of space and a proliferation in the number and kinds of payloads placed into space are inevitable future events made possible by the development of the Shuttle and various space technologies. The purpose and requirements of these payloads will differ widely and dictate the support configuration offering the greatest suitability and return-on-investment. Payloads may be placed on and supported by a freeflyer (i.e., a dedicated bus), an unmanned platform (i.e., a shared bus), the Space Station, or the Shuttle's Spacelab. Efficient and effective utilization of space resources depends on a proper matching between a payload and support platform.
>
> To ensure the best use of space resources, the Committee believes that it is necessary to establish guidelines for determining when it makes sense to put payloads on either a freeflyer, unmanned platform, the Space Station, or Spacelab. The Committee, therefore, directs NASA to develop selection criteria for each available support platform to better serve the payload community. These guidelines should be submitted to the Committee by January 1, 1985."

This report provides background information on carrier types and addresses the procedures for selection of carriers by non-NASA users, NASA Science and Applications payloads, and NASA technology missions. Advantages and disadvantages of carrier types are provided, and payload requirements are matrixed against carrier capabilities. A top-level listing of factors which must be considered in carrier selection has been developed, but it is impracticable to develop a detailed set of guidelines.

II. BACKGROUND

There are several types of carriers available. These include:

A. Suborbital Carriers: Sounding rockets, high altitude research balloons and research aircraft are used primarily to test new instrument concepts prior to assigning them to spacecraft, to carry payloads to measure the ambient atmosphere and space plasma environments and to conduct brief astronomical observations.

B. Free-flyers: Relatively small, self contained, carriers. Normally the payload consists of one or more instruments concentrating on a single major objective. The free-flyer can be at any orbital altitude or inclination. Most free-flyers have an on-orbit lifetime of more than a year. The free-flyer has traditionally not been reusable, therefore, a new carrier has had to be built for each payload, although NASA uses standard carrier designs such as the small Astronomy Satellites, the High Energy Astronomy Observatories, and the Multi-mission Modular Spacecraft whenever possible. A major emerging potential of the STS and particularly of the manned element of Space Station is the capability to repair, service and exchange the payload in free-flyers, thus extending their life and function. The recent repair and return to active operation of the Solar Maximum Mission is an example of this emerging capability. NASA does not provide free-flyer carriers except when NASA is a sponsor of the mission.

Both NASA and Europe are in the process of developing a new class of free-flying spacecraft launched by the Space Shuttle, deployed for a short mission, and then recovered and returned to earth by the Space Shuttle. One such European carrier has already flown. The NASA carrier, Spartan, will fly for the first time in mid-1985. Both carry small, sounding rocket class payloads.

C. Shuttle-attached Carriers: The Shuttle provides services to these carriers and the carrier, in turn, provides services to the payload. Services may include electrical power, thermal control, data handling, command and control, and pointing. The mission duration for these carriers is limited to the Shuttle stay time on orbit which is currently 10 days. The mission must be conducted in low earth orbit, although the STS can go to inclinations of 28^0 to 107 ° when both the Kennedy and Vandenberg launch complexes are operational. NASA provides these carriers to non-NASA users on a cost-reimbursable basis:

1. Intermediate Carriers: Intermediate carriers are those cargo bay attached, multi-use carriers that have less weight or volume capability than a Spacelab module or pallet. These various carriers can carry up to 2000 pounds, provide power, relatively limited control and data interfaces and, in some cases, may provide active cooling. Some members of this class are available now and others are being developed. The range of accommodations provided by this class facilitate the selection of carriers most appropriate to the needs of specific payloads. Two such carriers, Get Away Special (GAS) and Hitchiker are depicted in the enclosures.

2. Spacelab: A family of carriers including pressurized modules and pallets which can be flown in several different configurations. The module provides a shirt sleeve environment and the pallet(s) provide direct access to the space as well as accomodations for larger payloads. Depending on configuration, it can carry several tons of payload, provide up to 8 kilowatts of electrical power and handle data rates of up to 50 Mbps. It can be flown dedicated to one instrument or science objective or in a multiple instrument/discipline mode. Routine pointing is provided by the Orbiter, but if precision pointing is a payload requirement this can be satisfied by the Spacelab Instrument Pointing System. Control of the payload is possible direct from the ground, from the Spacelab computers or by the flight crew. At the top level, the capabilities of Spacelab are described in the STS Users Guide. The detailed

description of its capabilities is over a thousand pages long and is available only on request.

D. Space Station:

Space Station will consist of a manned element and one or more unmanned elements. Current plans call for a co-orbiting platform and a polar platform. Co-orbiting platform refers to a platform whose orbit permits convenient accessibility with the manned element at a to be determined frequency. Space Station will provide pressurized volumes and capability for mounting payloads for direct exposure to space. The size of an individual payload can be larger than on any other carrier. It will also provide the capability to repair and service co-orbiting platforms and free-flying spacecraft, thus extending their lifetimes and scientific usefulness. Since Space Station is still early in design, documentation describing specific capabilities will not be developed for some time. Articles describing general concepts of potential capability appear frequently in scientific and technical journals.

Comparisons of the capabilities of these various carriers with the advantages (+) and disadvantages (-) of each is given in Enclosures 2 - 8.

III. SELECTION OF CARRIERS BY NON-NASA USERS

A non-NASA user has the freedom to select the carrier which best fulfills the objectives of the mission. For example, a company which wishes to place a commercial communications satellite in geosynchronous orbit can choose to go to any company which currently manufactures such spacecraft or choose to develop a completely new spacecraft. It can then choose to have the spacecraft launched by the NASA Space Transportation System or can choose an alternate launch vehicle.

In a similar manner, a user can choose to use the NASA-operated Shuttle-attached carriers, develop a new Shuttle-attached carrier or choose an alternate.

Other carriers, both free-flyer and attached, are under consideration for development by industry. The carrier(s) will then be provided to a potential user by the developing company.

The only role which NASA fulfills during this carrier selection process is to advise the customer whether the candidate NASA-provided carriers can be made available when requested and which carriers will meet the requirements of the mission. NASA also assures itself that the proposed mission meets essential design standards. NASA provides to these customers information on the capabilities of the carriers and the process by which they can reserve space. The Johnson Space Center maintains and makes available to users a large library of documents which give information on the carriers.

Except for specific cases, such as planetary launches, a user from outside NASA has a higher priority for use of a NASA-provided carrier than does a NASA user.

Foreign governments, other U.S. government agencies, and all commercial concerns can choose to use NASA-provided carriers or can go to another source.

NASA has recently established an Office of Commercialization whose function is to inform industry of the potentials of space, advise them of the services which NASA can offer, and assist the customer in gaining access to space.

Since this selection process is not under the control of NASA, it is not possible for NASA to impose selection guidelines on the user.

IV. SELECTION OF CARRIER FOR NASA SCIENCE AND APPLICATIONS PAYLOADS

The majority of NASA-sponsored missions fall into this category. The number and type of carriers available to NASA-sponsored users is influenced by advisory committees to NASA, through international negotiations, and by deliberations associated with the budget process.

In every major area of activity, NASA maintains standing advisory committees, generally with a preponderance of membership from outside of NASA. In addition, the National Academy of Sciences and National Academy of Engineering maintain completely independent committees which provide advice to NASA. These committees recommend to NASA the types of activities which should be undertaken in space in both the near- and far-term. They look at the present and projected distribution of NASA resources and give guidance on directions and priorities or make recommendations for redistribution. The advisory committees look from five to twenty years in the future and provide recommendations on what science goals should be attained during this period. Based on the science objectives recommended by the Committee and NASA program offices, an engineering decision is then made on the optimum carrier for a particular set of objectives, using much of the same logic as depicted in Enclosures 2-8.

For areas of particular concern, NASA forms ad hoc advisory committees such as the recent Solar System Exploration Committee, Shuttle Science Working Group, and Astronomy Survey Committee or the current Task Force on Scientific Uses of the Space Station (TFSUSS) are formed to provide advice and direction. TFSUSS is considering what types of activities could profit by the existence of a Space Station, and what capabilities need to be designed into the Space Station to support these activities. In addition to TFSUSS, Committees and Working Groups in each of the science discipline areas are considering capabilities that the Space Station will have to have in order to be of advantage to their community. (Potential technological and commercial users of the Space Station are represented by separate working groups.) The design of the Space Station will be largely determined by the projected requirements generated in this process. Already the emphasis on the Manned Element of Space Station as a place from which to service and repair free-flyers has emerged through this process.

Both the advisory committees and the science discipline offices in NASA are well aware that the less expensive the carrier, the more frequently it can be made available. They are striving to maintain a balance between the less expensive carriers which can still support a number of types of valuable science investigations for individual investigators ("P.I.-class" investigations) and the larger facility class spacecraft which provide access to a large science community with the promise of major scientific breakthroughs. In particular, the frequency of sub-orbital opportunities on research aircraft, sounding rockets, balloons, and of "Explorer-class" free-flyer opportunities are carefully protected.

In some science disciplines, the nature of the science to be done dictates the choice of carrier. For example, the majority of our Life Sciences investigations demand a pressurized environment and would have to be accommdated by a carrier such as the Spacelab module or Space Station. Other types of investigations are relatively flexible as to carrier, but demanding of other parameters. For example, earth resources investigations frequently require a high inclination orbit although many different carriers can be employed depending on the magnitude of the resources required by specific instrument complements.

Only those missions which receive high recommendations from the advisory committees are submitted in the budget process. This process ultimately determines the types of payloads we will fly and consequently the number and type of carrier which will be available in each fiscal year.

When opportunities to participate in a given class of carrier flight are relatively infrequent, NASA employs the process described in NASA Management Instruction (NMI) 7100.11, "Announcement of Opportunity Process - Acquisition and Administration of Space Science Investigations" (Enclosure 9).

The Announcement of Opportunity (AO) process is used for NASA-sponsored free-flyers and Spacelab missions. In the event of a cooperative mission between NASA and another agency, the AO process is used for NASA's portion of the mission.

The AO typically describes the characteristics of the carrier which will be available and the overall science objectives of the mission. It solicits the submission of investigation proposals for participation in this opportunity. A user may propose to build an instrument to make a specific set of measurements or may propose to use a NASA-provided instrument or facility to perform his/her investigation. In some cases theoretical investigations based on the data obtained are also solicited. Each AO specifies which option(s) are available in the opportunity. The AO's are routinely mailed to an international list of approximately 14,000. A user may at any time request to be added to this list by writing to NASA. The list includes the entire membership of the American Astronautical Society, for example. In addition to this list, the sponsoring science discipline takes care to assure that all persons known to have participated in the NASA science program in that area is advised of the opportunity.

NASA employees compete equally with non-NASA proposers in this process. Foreign nationals may propose but must arrange for sponsorship and funding by their national space agency.

Two recent Announcements of Opportunity reflecting varying applications of this process are attached. They are AO No. OSSA-4-84, 15 October 1984, "Hubble Space Telescope" (Attachment 10) and A.O. No. OSSA-2-84, "Life Sciences Investigations in Space, 1986-1991" (Attachment 11).

All proposals received are evaluated through the process including peer review as described in NMI 7100.11.

When opportunities to participate in a given class of carrier are part of an on-going, frequent series - as is the case with sounding rockets, balloons, and research aircraft - NASA issues "Dear Colleague" letters. These letters inform the potential users that they may submit unsolicited investigation proposals at any time to participate in the opportunity. The "Dear Colleague" letters are distributed in the same manner as the Announcements of Opportunity. All unsolicited proposals received are evaluated periodically (generally annually) through the same process as described in NMI 7100.11. "Dear Colleague" letters are typically updated and reissued every few years.

Although it is not yet possible to be specific about Space

Station opportunities, it is very likely that we will use the AO process for the class of experiment on the Space Station that will require a significant investment of resources and the "Dear Colleague" process for more frequently available opportunities.

V. NASA TECHNOLOGY MISSIONS

These are missions which support the NASA requirements for the development of new technologies. The need arises from the NASA ground research program or from projects currently in development. Whenever it is necessary to test a new technology in space, that experiment is prioritized among other needed technology experiments and then accomplished as funding permits. In all cases, the least expensive carrier is chosen in order to maximize the number of experiments which can be flown.

VI. SUMMARY

The establishment of science objectives is greatly influenced by our advisory committees. The selection of a carrier to accomplish these objectives is an engineering decision based on numerous variables. The opportunity for a user to participate in a majority of NASA-sponsored missions is provided to the science community through the Announcement of Opportunity or "Dear Colleague" process. The community has been familiar with this process and has been supportive. We plan to continue to use this approach.

Descriptions of the carriers which NASA maintains and provides to non-NASA users are provided to all persons on large mailing lists. A potential user can have his/her name placed on these lists by request to NASA. In addition, a library is maintained at the Johnson Space Center which contains detailed information on both NASA-provided and non-NASA carriers used in conjunction with the Space Transportation System.

A top-level listing of some of the factors which must be considered when a carrier is to be selected has been developed and is given in Enclosures 2-8. However, in the actual selection process, it is necessary to provide a greater level of detail, to bring other factors into play and to make trades between candidate carrier~~s.~~ Carrier selection may also be made for reasons that maximize the programmatic objective of a group rather than individual instruments or payloads. It is not practical to establish a more detailed set of guidelines which would make these considerations and trades for all possible users.

NASA has expended great effort and will continue to work to make the capabilities of potential carriers and the opportunity to participate in NASA-sponsored missions known to all interested parties and to assure that representatives of the several user communities are included in the carrier selection process.

Enclosure 1

NASA Educational Briefs

An Educational
Publication
of the
National Aeronautics
and Space Administration

For the
classroom

NASA'S GETAWAY SPECIALS

On STS-5, the fifth mission of NASA's Space Transportation System (STS), NASA's Space Shuttle carried a Federal Republic of Germany experiment into orbit. The experiment tested how molten mercury and gallium metals mixed in the microgravity (nearly weightless) environment of space.

On STS-4, NASA's Space Shuttle carried a canister containing nine experiments by students of Utah State University and Weber State College (Ogden, Utah). The experiments observed the effects of microgravity on growth of fruit flies, brine shrimp, algae, and duckweed; on alloying and soldering; on surface tension; and on curing of composite materials.

These were the first two of NASA's Getaway Specials. Future Getaway Specials will carry experiments by such disparate organizations as a large aerospace firm, a public school district, and a motion picture producer. The organizations are among more than 250 individuals and organizations, domestic and foreign, that have either made a $500 down payment or paid in full for more than 350 Getaway Special reservations.

What Is a NASA Getaway Special?

Getaway Special is the popular name for the Self-Contained Payload Program of NASA's STS. Through the program, individuals and organizations, both private and public, of all countries are given an opportunity to send scientific research and development experiments of their own choosing into space aboard NASA's Space Shuttle orbiter at comparatively modest cost.

Why Does the NASA Space Shuttle Carry Getaway Specials?

The orbiter is the part of the Space Shuttle in which people and cargo are transported between the ground and Earth orbit. The orbiter has a cavernous payload bay about 18.3 meters (60 feet) long and 4.6 meters (15 feet) in diameter. The orbiter may carry a payload as heavy as 20,500 kilograms (65,000 pounds) into Earth orbit.

For the most part, the payload bay will accommodate application and scientific spacecraft and/or manned laboratories which come in a variety of shapes and sizes. These primary payloads, as they are referred to, on the average do not use all of the orbiter's payload capacity and may leave room for smaller experiments. As a result, NASA is able to offer Getaway Specials at low cost on a space-available basis.

What Do Getaway Specials Cost?

Getaway special fares are based on container volume required and on experiment weight. NASA prices for flights of Getaway Specials through 1985 are presented in Table 1 below.

TABLE 1

GETAWAY SPECIAL PRICES

Container Volume		Experiment Weight		Price In
Cubic Meter	Cubic Feet	Kilograms	Pounds	U.S. Dollars
.07	2½	27.2	60	$ 3000
.07	2½	45.4	100	5000
.14	5	90.7	200	10000

The containers to which the table refers are the *NASA standard containers* for Getaway Special payloads. The containers are cylindrical and are 50.2 centimeters (19.97 inches) in diameter. The .07-cubic-meter container is 35.89 centimeters (14.13 inches) long. The .14-cubic-meter container is 71.6 centimeters (28.25 inches) long.

Container bottoms and sides are insulated. A selection of container tops (mounting plates) is available. Some, like the one that is openable or the one that is optically transparent, are optional at extra cost. The container may be sealed or, if a space vacuum is needed, vented.

What Are Getaway Special Requirements?

Like all carriers, NASA's Space Transportation

System has established standards and conditions relating to Getaway Specials. These are detailed in *14 Code of Federal Regulations, subpart 1214.9.* Among its key provisions are the following.

- In order to assure access to space by a diverse group of users, NASA will rotate Getaway Special flights among three major categories: educational, commercial, and U.S. Government. Within each group, Getaway Specials will be flown on a first-come first-served basis.
- Payloads must fit NASA standard containers and must not be heavier than 90.7 kilograms (200 pounds). Two or more payloads may be included in a single container if they fit into it and do not exceed weight limitations.
- The payloads must be peaceful in intent, be safe, and be in compliance with all laws and U.S. Government obligations.
- Experiments with live animals must be humane in accordance with U.S. Government guidelines.
- The payload should require no more than six simple inputs (such as turning a switch on and off three times) by the Shuttle crew.
- The payload must be self-powered and not draw on the Shuttle orbiter's electricity.
- The package containing the payload must have mounting lugs that will attach to the mounting plate that NASA provides.
- A Getaway Special may be shared by more than one party. However, NASA prefers to deal with only one selected representative of the group.
- A user may have more than one Getaway Special on a flight. NASA does not, however, guarantee that the separate containers will be adjacent or connected.
- Transfer of ownership or use of a Getaway Special requires NASA consent.
- Although NASA requires only minimal information when a Getaway Special launch services agreement is signed, it must be provided with detailed information no later than 18 months before the user's earliest acceptable launch date. This information is needed to help NASA determine whether the payload complies with standards such as safety and peacefulness. NASA will not, however, act as a judge of the scientific merit or practicability of the experiment.

What Does NASA Provide?

Among standard services provided Getaway Special users by NASA are:

- A NASA shipping container for transportation of the payload to Kennedy Space Center, Florida, and a container for Shuttle flight.
- Choice of container atmosphere, such as dry nitrogen, dry air, or a vacuum.
- Payload safety reviews. Additional fees will be assessed if unusually complex procedures or tests are required.
- Pre-integration storage of the payload at Kennedy Space Center and limited access to the payload by the user.
- Installation in and removal of payloads from NASA standard containers at Kennedy.
- Installation in and removal of containers from the Shuttle orbiter.
- Services aboard the Space Shuttle orbiter in space.
- Returning payload to user at Kennedy and providing user with a document containing such information as orbital parameters, space flight dates, mission profile, and payload operation time.

From Whom Do I Obtain Additional Information?

For additional information about NASA's Getaway Special program, contact Ms. Donna S. Miller, Code MC-7 NASA Headquarters, Washington, D.C. 20546. NASA's Goddard Space Flight Center, Greenbelt, MD., is the primary technical contact for Getaway Special users. It can provide planning and technical information and advise on space-qualified components such as timers, recorders, and batteries. These consultations are usually without charge.

ACTIVITIES AND QUESTIONS FOR THE CLASSROOM

1. Have each student suggest an experiment that would be affected by vacuum or microgravity.
2. Evaluate experiments on the bases of scientific merit and practicality.
3. Describe and discuss the scientific method and apply its procedures to your selected experiment.
4. Have the student determine the size of the standard container needed and estimate experiment weight for each experiment.
5. Narrow down the experiment to a select few or one that is most suitable to fly as a Getaway Special aboard the Space Shuttle.

Last of three Getaway Specials is installed in payload bay of Space Shuttle orbiter *Challenger* during preparations for STS-6 mission. It contains experiments by Park Seed Company to study effects of varying space environments on seeds. The two longer canisters contain an experiment by Asahi Shimbum (Rising Sun Newspaper) of Japan on growth of snowflakes and experiments by the U.S. Air Force Academy in biology and materials processing.

Enclosure 2

SELECTION OF SUPPORT PLATFORMS FOR PAYLOADS ACCOMMODATION FACTORS

SELECTION CRITERIA	FREE FLYER	SHUTTLE S/L	SPACE STATION		
			MANNED ELEMENT	UNMANNED (CO-ORBIT)	UNMANNED (POLAR)
P/L DESIGN REQUIREMENTS					
- POWER					
* LOW	X	X	-	-	-
* MODERATE	-	-	X	X	X
- COOLING					
* PASSIVE	X	-	-	-	-
* ACTIVE	-	X	X	X	X
- LARGE PAYLOAD CAPACITY	-	X	X	X	X
- PAYLOAD ACCESSIBILITY	-	X	X	X	-
- SAMPLE / FILM RETURN	-	X	X	X	X
- MAINTAINABILITY	X	X	X	X	X
PAYLOAD ORBITAL REQUIREMENTS					
- ALTITUDE					
* HIGH	X	-	-	-	-
* LOW	X	X	-	-	-
* FIXED	-	-	X	X	X
* FLEXIBLE	X	-	-	-	-
- INCLINATION					
* HIGH	X	-	-	-	X
* LOW	X	-	X	X	-
* FLEXIBLE	-	X	-	-	-
- ATTITUDE ADJUSTMENT	-	X	-	-	-
- LOW GRAVITY/ STABILITY	X	-	-	X	X
- CONTAMINATION FREE	X	-	-	X	X
- MINIMAL P/L VIEWING DISTURBANCES	X	-	-	X	X
- AUTONOMY - ORBITAL PARAMETERS (LAUNCH DATE, TIME, ETC.)	X	X	-	-	-
PAYLOAD INTEGRATION/ OPS REQUIREMENTS					
- LONG DURATION	X	-	X	X	X
- SHORT DURATION	-	X	-	-	-
- FREQUENT DETECTOR MODIFICATION	-	X	X	-	-
- ORBITAL SERVICING/ RESUPPLY	-	X	X	X	X

Enclosure 3

TABLE 1

FREE FLYER (DEDICATED BUS)

(+) LOW CONTAMINATION
(+) EXTENDED PERIODS OF LOW GRAVITY OBTAINABLE
- NO ACTIVITY TO CREATE DISTURBANCES

(+) ALTITUDE & INCLINATION
- AVAILABILITY DEPENDENT ON SHUTTLE DELIVERY AND S/C PROPULSION CAPABILITY
- HIGHLY ELIPTIC OR HIGH ALTITUDE ORBITS

(+/-) LONG DURATION
- LIFE AS LONG AS SERVICES LAST
- RELIABILITY/ REDUNDANCY BUILT IN

(+/-) AUTONOMY
- NO INTERFERENCE FROM OTHER SYSTEMS

(+/-) DEDICATED DISCIPLINE
- COMPETITION FOR ACCOMMODATIONS LIMITED

(-) POWER
- RELATIVELY MODEST AMOUNTS OF POWER AVAILABLE

(-) PAYLOAD SIZE
- RELATIVELY SMALL SIZE PAYLOADS

Enclosure 4

TABLE 2

HITCHHIKER

- (+) REUSABLE INSTRUMENTS
  - INSTRUMENTS MAINTAINED/RETURNED FOR REPAIR OR OVERHAUL
- (+) GROUND CALIBRATION ACHIEVABLE
  - SHORT DURATION MISSIONS
- (+) ALTITUDE
  - ORBITS FROM 100-300 N.MI. ALTITUDE
  - ALTITUDE SHIFT CAPABILITY
  - SATISFACTORY TO MAJORITY OF THE USERS
- (+) INCLINATION
  - A RANGE OF INCLINATIONS AVAILABLE
  - SATISFACTORY TO MAJORITY OF USERS
- (+) PAYLOAD SIZE
  - SMALL PAYLOADS ACCOMMODATED
- (+/-) VIEWING & POINTING CAPABILITY
  - ORBITER MANEUVERS TIMELINED TO PROVIDE DESIRED VIEWING OPPORTUNITIES
  - GROSS POINTING CAPABILITY BUILT INTO THE ORBITER
- (+/-) SHORT DURATION
  - MAXIMUM TIME AVAILABLE (7 - 10 DAYS)
- (-) POWER
  - LIMITED POWER TO PAYLOADS
- (-) DATA RETRIVAL
  - RELATIVELY LOW CAPABILITY
- (-) CONTAMINATION
  - GLOW, WATER DISCHARGE, RCS/OMS FIRING CONTAMINATE ENVIRONMENT AROUND THE ORBITER
- (-) LOW G DISTURBANCES
  - MANNED PRESENCE AND THRUSTER FIRINGS PRODUCE MINIOR ACCELERATIONS

Enclosure 5

TABLE 3

GAS CAN (GET AWAY SPECIAL)

(+) REUSABLE INSTRUMENTS
(+) ALTITUDE
  * ORBITS FROM 100-300 N.MI. ALTITUDE
  * ALTITUDE SHIFT CAPABILITY
(+) INCLINATION
  * A RANGE OF INCLINATIONS AVAILABLE
(+/-) SHORT DURATION
  * MAXIMUM TIME AVAILABLE (7 - 10 DAYS)
(-) POWER / DATA / CONTROL
  * AUTONOMOUS PAYLOAD CONTROLLER
(-) LOW G DISTURBANCES
  * MANNED PRESENCE AND THRUSTER FIRINGS PRODUCE MINIOR ACCELERATIONS
(-) PAYLOAD SIZE
  * SMALL PAYLOADS (200 LBS) ACCOMMODATED
(-) NO VIEWING OR POINTING CAPABILITY

Enclosure 6

TABLE 4

SPACELAB

(+) ACTIVE MAN INTERACTION
- PAYLOADS MOUNTED FOR CREW ACCESSABILITY
- SAMPLES AND FILM CHANGED OUT ON-ORBIT
- MAN AVAILABLE TO INTERACT WITH INSTRUMENT/EXPERIMENT

(+) REUSABLE INSTRUMENTS
- INSTRUMENTS MAINTAINED/RETURNED FOR REPAIR OR OVERHAUL

(+) GROUND CALIBRATION ACHIEVABLE
- SHORT DURATION MISSIONS

(+) ALTITUDE
- ORBITS FROM 100-300 N.MI. ALTITUDE
- ALTITUDE SHIFT CAPABILITY
- SATISFACTORY TO MAJORITY OF THE USERS

(+) INCLINATION
- A RANGE OF INCLINATIONS AVAILABLE
- SATISFACTORY TO MAJORITY OF USERS

(+) PAYLOAD SIZE
- LARGE PAYLOADS ACCOMMODATED

(+) DATA
- RELATIVELY HIGH CAPABILITY
- ENTIRE RESOURCE SUPPLIED TO A SINGLE INSTRUMENT ON A TIME SHARED BASIS

(+/-) VIEWING & POINTING CAPABILITY {PALLET(S)}
- ORBITER MANEUVERS TIMELINED TO PROVIDE DESIRED VIEWING OPPORTUNITIES
- GROSS POINTING CAPABILITY BUILT INTO THE ORBITER
- FINE POINTING SYSTEMS AVAILABLE

(+/-) DEDICATED OR MIXED DISCIPLINE
- MULTIPLE DISCIPLINES MAY BE FLOWN TOGETHER TAKING MAXIMUM ADVANTAGE OF AVAILIBLE RESOURSES

(+/-) SHORT DURATION
- MAXIMUM TIME AVAILABLE (7 - 10 DAYS)

(-) POWER
- POWER AVAILABLE FORHIGH POWER USERS (TIMELINED)

(-) CONTAMINATION
- GLOW, WATER DISCHARGE, RCS/OMS FIRING CONTAMINATE ENVIRONMENT AROUND THE ORBITER

(-) LOW G DISTURBANCES
- MANNED PRESENCE AND THRUSTER FIRINGS PRODUCE MINIOR ACCELERATIONS

NOTE: SPACELAB PAYLOAD ACCOMMODATIONS HANDBOOK IDENTIFIES SPECIFIC CARRIER CHARACTERISTICS

Enclosure 7

TABLE 5

SPACE STATION - MANNED ELEMENT

(+) REUSABLE INSTRUMENTS
  - INSTRUMENTS MAINTAINED/RETURNED FOR REPAIR
  - SAMPLES & FILM CHANGED OUT ON ORBIT

(+) PAYLOAD SIZE
  - RELATIVELY LARGE PAYLOADS ACCOMMODATED

(+) LONG DURATION
  - RESOURCES REPLENTISHED
  - CARRIER RELIABILITY AND REDUNDANCY BUILT IN

(+) POWER
  - LARGE POWER SOURCE SHARED AND TIMELINED AS NECESSARY

(+) COOLING
  - LARGE ACTIVE COOLING CAPABILITY AVAILABLE

(+/-) ALTITUDE & INCLINATION
  - ALTITUDE LIMITED BY SHUTTLE CAPABILITY

(+/-) VIEWING & POINTING
  - ORIENTATION FOR STABILITY MAY RESTRICT SOME DESIRED VIEWING REQUIREMENTS
  - FINE POINTING SYSTEMS AVAILABLE

(-) CONTAMINATION
  - MANNED PRESENCE AND ORBITAL MAINTENANCE

(-) LOW G DISTURBANCES
  - MANNED PRESENCE, REBOOST AND SERVICING ACTIVITIES

Enclosure 8

TABLE 6

SPACE STATION - UNMANNED ELEMENT { CO-ORBITING & POLAR}

(+) REUSABLE INSTRUMENTS
- INSTRUMENTS MAINTAINED/RETURNED FOR REPAIR
- SAMPLES & FILM CHANGED OUT ON ORBIT

(+) PAYLOAD SIZE
- RELATIVELY LARGE PAYLOADS ACCOMMODATED

(+) CONTAMINATION FREE ENVIRONMENT

(+) LOW GRAVITY
- DISTURBANCES LIMITED TO REBOOST PHASE AND SERVICING

(+) LONG DURATION
- RESOURCES REPLENTISHED
- CARRIER RELIABILITY AND REDUNDANCY BUILT IN

(+) POWER
- LARGE POWER SOURCE SHARED AND TIMELINED AS NECESSARY

(+) COOLING
- LARGE ACTIVE COOLING CAPABILITY AVAILABLE

(+/-) VIEWING & POINTING
- ORIENTATION FOR STABILITY MAY RESTRICT SOME DESIRED VIEWING REQUIREMENTS
- FINE POINTING SYSTEMS AVAILABLE

(+/-) ALTITUDE
- PREESTABLISHED ORBITAL CONSTRAINTS

{POLAR}

(+/-) INCLINATION
- SATISFIES MANY HIGH INCLINATION DISCIPLINE REQUIREMENTS

(CO-ORBITING)

(+/-) INCLINATION
- SATISFIES MANY LOW INCLINATION DISCIPLINE REQUIREMENTS

Enclosure 9
(Example)

NMI ✓ 7100.11

June 20, 1975
Effective date

Responsible Office: SS/Deputy Assoc. Admin. (Sciences)

Management Instruction

SUBJECT: ANNOUNCEMENT OF OPPORTUNITY PROCESS - ACQUISITION AND ADMINISTRATION OF SPACE SCIENCE INVESTIGATIONS

1. PURPOSE

The purpose of this Instruction is to complement the guidelines contained in NHB 8030.6 "Guidelines for Acquisition of Investigations" with regard to investigations obtained by the Office of Space Science (OSS) through the Announcement of Opportunity process. It is the intent to define and clarify roles and responsibilities of participants in the acquisition and administration of such investigations and to provide direction for the preparation of Announcements of Opportunity.

2. APPLICABILITY

This Instruction is applicable to the Headquarters Office of Space Science and to the NASA Field Installation assigned responsibility for the management or support of space science programs and projects (Project Centers).

3. DEFINITIONS

See Attachment A.

4. RELATED ISSUANCES

a.	NHB 8030.6	-	Guidelines for Acquisition of Investigations
b.	NMI 7121.1B	-	Planning and Approval of Major Research and Development Projects
c.	NHB 7121.4	-	Guidelines for Project Planning

Enclosure 10
(Example)

National
Aeronautics and
Space
Administration

15 OCTOBER 1984

A.O. NO. OSSA-4-84

Announcement of Opportunity

HUBBLE SPACE TELESCOPE

LETTERS OF INTENT - NOVEMBER 26, 1984

PROPOSALS DUE - MAY 17, 1985

Enclosure 11

(Example)

NASA
National
Aeronautics and
Space
Administration

A. O. No. OSSA-2-84

May 15, 1984

Announcement of Opportunity

LIFE SCIENCES INVESTIGATIONS IN SPACE
1986-1991

PROPOSAL DUE DATES: October 1, 1984
April 1, 1986
October 1,1987

APPENDIX 10

NASA
National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

JAN 31 1985

Honorable Don Fuqua
Chairman
Committee on Science and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

In the House Authorization Report 98-629, the Committee requested NASA to look at those institutions which have significant enrollments of minorities who are underrepresented in science and engineering in order to find ways to build closer relations with such schools, meet NASA's research objectives and increase the number of individuals from underrepresented groups in graduate research. The Committee instructed NASA to develop a plan by January 31, 1985, which would contain options for accomplishing these objectives.

In May 1984, NASA established the NASA Advisory Committee on Minority Graduate Researchers (NAC/MGR), to help us look at ways to meet this challenge. The advisory committee reviewed many issues related to the objectives, met with some of NASA's key line managers and submitted its final report October 29, 1984. The Committee recommended that NASA Centers and selected universities enter into R&D agreements which meet the above objectives; that grants for minority graduate students be awarded through principal investigators at selected universities; that principal investigators at major universities be given incentives to include minority graduate students on their research projects; and that NASA increase minority representation in its Graduate Student Researchers and other relevant programs.

The recommendations of the NAC/MGR have been reviewed and carefully studied. We have developed a plan which takes into account those recommendations and includes activities which will begin in FY 1985.

We will take a three-pronged approach to implement the plan which includes (1) establishment or expansion of our R&D relationship with a few selected universities; (2) the encouragement of principal investigators to add underrepresented minorities to their research grants; and (3) the increased participation of universities with substantial numbers of underrepresented minorities in our Co-op programs, faculty summer assignments, graduate students researchers, post doctoral fellowships and other programs.

Nothing in this expanded effort is intended to lessen our relationships with or support for the Historically Black Colleges and Universities; and I anticipate that the above plan to focus on additional universities that have underrepresented minorities will help achieve the objectives which you and I share.

Sincerely,

James M. Beggs
Administrator

cc: Honorable Manuel Lujan, Jr.

APPENDIX 11

Joint
Oceanographic
Institutions Incorporated
2100 Pennsylvania Ave., N.W., Room 316, Washington, D.C. 20037 Phone-(202)331-9438 Cable Address JOIINC

5 February 1985

The Honorable Don Fuqua
United States House of Representatives
Committee on Science and Technology
Rayburn House Office Building
Washington, D.C. 20510

RECEIVED
[illegible]
COMMITTEE ON SCIENCE
AND TECHNOLOGY

Dear Congressman Fuqua:

I am writing to bring to your attention an important issue in our nation's space science and applications program, the need for support of satellite oceanography. As you are aware, the United States has been the leader in scientific investigations of the oceans, and in particular of the oceans from space. The oceans are a key to our nation's economy and space technology offers the only opportunity for truly global synoptic, or snapshot, descriptions of the world oceans.

In response to this need, the oceanographic science and engineering community has developed a program of measurements from space as outlined in the enclosed report on "Oceanography from Space". The first mission in the proposed series is the Navy Remote Ocean Sensing System, NROSS, which was a new start in FY 1985 and which will fly in 1990 for a three year mission to measure global winds at the ocean surface.

The second mission in the series is the Ocean Topography Experiment, TOPEX, currently planned as a joint U.S./French mission, TOPEX/Poseidon, to measure global ocean surface topography for inference of ocean currents. TOPEX/Poseidon had been proposed by NASA as a new start for FY 1986 and flight in 1990. Unfortunately, the Administration budget for NASA as released this week does not include any new starts, and thus TOPEX/Poseidon faces at best a serious delay in launch.

It is crucial for our understanding of long-term weather and climate that we measure the winds (NROSS) and the currents (TOPEX/Poseidon) simultaneously. The French participation in the program not only reduces the cost significantly, but also allows important interaction with a strong foreign oceanographic community. We need to find a way to continue the TOPEX/Poseidon mission so that the satellite can be launched in the same time period as NROSS. If we cannot find such a way, we stand to lose the participation of the French, who need a firm commitment this year.

I enclose a set of documents that describes TOPEX/Poseidon and the scientific and application programs that it contributes to. I appreciate your help in considering this issue.

Yours sincerely,

D James Baker

D. James Baker
President

Oceanography from Space -- A Unique Opportunity

The unexpected and severe winter cold over much of the nation in January dramatically illustrates our vulnerability to climatic anomalies. Yet the prediction of these and other climate changes like the El Nino of 1982-1983 and the longer-term effects of increasing carbon dioxide in the atmosphere is not adequate. Climate change affects a large segment of our economy from the Florida citrus grower to the Kansas farmer; therefore our nation needs to have the best predictions possible. Experts now agree that such prediction depends critically upon understanding the role of the ocean in the climate system. It is fortunate and timely that new space technology promises the necessary global synoptic descriptions required and that new computer resources are ready to help analyze and model the data.

Major progress in oceanography in the past decade has laid the basis for significant advances with the new technology. We know that heat transport by ocean currents is key to reducing climatic extremes, but we also know that ocean eddies, the oceanic equivalent of atmospheric storms, dominate the energy of the ocean. The currents, the eddies, and the driving forces: winds, radiation, and mass flux at the ocean surface must all be measured simultaneously and globally if we are to be able to construct predictive models to run on the new supercomputers.

The World Climate Research Program, aimed at producing improved understanding and predictions of climate, provides an international context for the required ocean studies through its subprograms the Tropical Ocean Global Atmosphere program and the World Ocean Circulation Experiment. These programs are designed to measure the relevant oceanic and atmospheric parameters. Central to these programs is the need for global data, taken simultaneously all over the Earth for multiyear periods. Such data can be obtained only by satellite-borne instrumentation, appropriately complemented by in situ studies. The carbon dioxide issue highlights the importance of global biogeochemical cycles to life on earth and has stimulated the planning for a cooperative, interdisciplinary, international program of global change. Once again, satellite measurements of global processes, particularly ocean biology, are the key to understanding the interactions.

The ocean science community has recognized the unique and fundamental role for satellites in acquiring the necessary global data sets by developing a phased plan for oceanography from space, a series of four satellite missions for ocean physics, biology, and geodesy. The first of these is the Navy's Remote Ocean Sensing System, approved as a new start in last year's budget and to be flown in 1989. NROSS will provide operational information on ocean waves and eddies, and research data on surface winds.

The second of the series is proposed to be a joint U.S. French mission, TOPEX/Poseidon, that will measure the shape of the ocean surface and hence ocean currents. Together with the ocean surface winds provided by NROSS, the global data on ocean currents revealed by TOPEX/Poseidon will provide for the first time a synoptic global description of ocean circulation for use in computers for predictive models. TOPEX/Poseidon is ready for budget approval now: mission studies have been conducted over the past five years, and the satellite design studies have been completed by industry. Low-risk, flight-proven technology has been used. The French participation, with launch from Ariane, provides a significant savings in cost from a solely U.S. mission and continues a valuable international cooperative effort. Approval this year of the joint mission would allow flight in 1990, thus providing the necessary simultaneous measurements of currents and winds during the period 1990 - 1993. Without such data, we cannot hope to understand the physics of long-term air-sea interaction as a basis for long term weather and climate prediction.

The third and fourth step in the satellite series involve biology and geodesy. NASA is currently investigating flight opportunities for ocean color measurements which allow determination of chlorophyll content of the surface layers and for flow visualization. This mission has been recommended by the ocean science community as a new start in 1987. For measurements of the Earth's gravity and magnetic field, the Geopotential Research Mission is proposed for a new start in 1988 and deployment in 1991. The overall program provides for simultaneous observations of ocean processes in the early 1990's.

This program of approved and proposed satellite missions provides a unique opportunity for simultaneous study of interactive processes in the early 1990's. By coming to a general consensus, the oceanographers have put together a plan that opens the door to new understanding and prediction of environmental change that could have major impact on climate prediction and other aspects of our nation's economy. The new data is central to predictive systems for protection and control of our Exclusive Economic Zone, fisheries conservation and management, off shore oil and gas exploration, and mineral and power extraction. Through satellites and computers the ocean sciences are on the verge of a quantum jump in description and understanding. The new programs should have high priority in the nation's science program.

Ocean Topography Experiment (TOPEX)

Two-thirds of the Earth is covered by life-sustaining oceans. The extent to which the oceans modulate climate is determined largely by ocean currents which redistribute heat around the globe. The topography of the ocean surface is a direct indicator of the speed and direction of ocean currents, and the measurement of ocean surface topography is essential to determining the oceans' general circulation. Presently, the principal means of observing ocean currents is from ships and buoys, from which only very limited data can be obtained. Satellites offer the potential to obtain global measurements of ocean properties and behavior in a way never before possible. NASA's Seasat, a proof-of-concept oceanographic satellite launched in 1978, demonstrated clearly this ability to utilize advanced remote sensing techniques to monitor the oceans from space. Onboard Seasat was a third generation radar altimeter system which measured ocean surface topography with a precision never before obtained from space, and which permitted a number of innovative research investigations into ocean current behavior.

Building on the success of Seasat, TOPEX--a dedicated, free-flying, altimetric satellite--is being proposed to provide a basis for improving our understanding of the general circulation of the global oceans. TOPEX will use radar altimetry to measure the surface topography of the oceans which, when combined with appropriate in situ observations--such as those planned for the World Ocean Circulation Experiment (WOCE)--will enable a determination of the three-dimensional structure of the ocean currents. When further combined with scatterometer winds from the NASA Scatterometer (NSCAT) to be flown on the Navy Remote Ocean Sensing System (N-ROSS), a unique, never before seen, view of the oceans' driving force (winds) and the resulting ocean response (topography) will have been obtained. Such a view of the global oceans could provide a fundamental breakthrough in improving our understanding of the ocean's role in climate variability.

Results of the studies conducted by NASA over the past four-and-a-half years have shown that TOPEX is a scientifically important mission, is technically feasible, and can be accomplished in a cost-effective manner with low risk. Satellite definition studies with industry--Fairchild, RCA, and Rockwell--are nearing completion and have verified the approach to minimize risk by using a flight-proven satellite bus with minimum modifications. A brassboard model of the proposed TOPEX radar altimeter system is currently under development. A joint study with the French Space Agency (CNES) has recently been completed confirming the technical feasibility and significant scientific benefits of a NASA/CNES collaborative mission, whereby CNES would launch TOPEX using Ariane in exchange for scientific collaboration and the flight of a French altimeter and a French satellite tracking receiver. Collaboration between NASA and CNES on TOPEX would substantially broaden the scientific base for exploitation of the data, would make available technical and scientific expertise to complement ours, and would greatly expand the resources that could be brought to bear on the analysis and utilization of the data. Earliest launch of TOPEX would be in late 1990 followed by three years of data acquisition and analysis. In addition to utilizing WOCE in-situ observations, TOPEX will be a key contributor to WOCE, with TOPEX topography measurements being central to achieving the scientific objectives of WOCE--a component of the World Climate Research Program (WCRP).

FY 1986 New start request: $20 Million.

APPENDIX 12

NASA
National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

FEB 26 1985

Honorable Don Fuqua
Chairman
Committee on Science and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

In the Report 98-629, dated March 21, 1984, which accompanied H.R. 5154, the NASA Authorization for FY 1985, the Committee on Science and Technology requested NASA provide a preliminary timetable and rationale for the completion of activities to fence all of the Shuttle's operating budgets, facilities, and personnel. This request reflected recommendations made by the NASA Advisory Council (NAC), based on perspectives gathered in late 1982 and early 1983. Since that time, NASA has made significant changes in the manner in which the Shuttle Operations budget is structured and in the Shuttle organizations at the field centers. During the same period, the Shuttle Program transitioned from a mix of development and operations activities to almost exclusively operations activities with attendant consolidation of support contractors. The aggregate impact of these programmatic changes has been to segregate, to a very large degree, the Shuttle Operations within NASA while better focusing management responsibilities, allocation of funds, program controls, and accountability.

To accomplish the intent of the Committee's request, I established an internal NASA review group in the Office of Space Flight (OSF), chaired by Charles Gunn, and an external review group, the Shuttle Operations Strategic Planning Group, chaired by Ed Smylie, the former Associate Administrator for Space Tracking and Data Systems. The OSF team was charged to assess Shuttle Operations and recommend further actions to fence the program. The team's summary report is enclosed and concludes that the restructuring of budgets and organizations has essentially accomplished the fencing of Shuttle Operations within the Agency. This conclusion anticipates near-term reorganization within the OSF to better focus on administration of policies, requirements, and issues dominant in operations as opposed to acquisition and development.

In summary, I believe that since the NAC made its recommendation to fence Shuttle Operations, the program has taken a number of steps which effectively segregate, insofar as practical, the Shuttle Operations from NASA's other programs. When the Shuttle Operations Strategic Planning Group completes their activity, we will communicate their findings to the Committee.

Sincerely,

James M. Beggs
Administrator

Enclosure

cc:
Honorable Manuel Lujan, Jr.
Honorable Bill Nelson
Honorable Robert S. Walker
Honorable Harold L. Volkmer

REPORT TO CONGRESS ON SHUTTLE OPERATIONS FENCING

Introduction

House of Representatives Report 98-629, requires NASA provide the Committee on Science and Technology, by December 31, 1984, a preliminary timetable and rationale for the completion of activities to fence all of the Shuttle's operating budgets, facilities, and personnel. In response, the Office of Space Flight (OSF) commissioned a team composed of members of NASA Headquarters and each of the field centers engaged in Shuttle operations. The team was chartered to assess those steps already taken or to be taken to segregate within NASA the allocation, control, and accounting of Shuttle operations budgets, personnel, and facilities. The team membership is provided in Enclosure 1.

In October 1983, the NASA Advisory Council (NAC), issued the report "Study of the Mission of NASA," recommending that operating budgets, facilities, and personnel required to support an operational Space Shuttle be "fenced" from the rest of NASA's programs. This recommendation was based on perspectives gathered in late 1982 and early 1983. Since then, the Space Shuttle Program has made major changes in the budget structure used to present and to control Shuttle operations funding requirements and requests to Congress. In the same period, the Shuttle operations management organizations, both at Headquarters and at the field centers, have been restructured, while the work of the Shuttle prime contractors has shifted almost exclusively to operations from a previous mix of development and operations. Also, the support contracts for operations have been shifted from cost to incentive form, and parallel development tasks have been excluded. The combined impact of these changes has been to segregate Shuttle operations budgets and organizations within the Agency and to more clearly delineate and focus management responsibilities, allocation of funds, program controls, and accountabilities. The rationale for these fencing actions, motivated by the NAC recommendations and NASA's planned future actions, are addressed here in three categories: budget, organization, and facilities.

In the conduct of the NASA team's review of Shuttle operations, the team defined "fencing" as a discernable, structured segregation of a program element or function within NASA as identified by separate budget line, funding allocation, funding control, aggregation of cost, cost accountability, and by separate organization design, setting, and management control. Also, fundamental to the NASA team's deliberations was the assumption that the Space Shuttle is integral to the mission and role of NASA and, for the foreseeable future, Shuttle operations will remain within the Agency.

Budget

At the time the NAC recommended fencing of the operations budget and prior to the NASA 1984 Fiscal Year (FY) Congressional budget, NASA activities were funded in three appropriations: Research and Development (R&D), Constructions of Facilities (CofF), and Research and Program Management (R&PM). Within the R&D appropriations, Shuttle Operations has been aggregated and presented to the OMB and Congress within a single funding line. The FY 1982 NASA budget structure illustrates this in Enclosure 2. Starting in FY 1984, in response to Congressional requests, a new appropriation, Space Flight, Control and Data Communications (SFCDC), was established from the R&D appropriation as shown in Enclosure 3. This fourth appropriation encompasses the Tracking and Data Acquisition budget, the nonrecurring Shuttle Production and Operational Capability budget, and the STS Operations budget. Further, the budget justification and operating controls for Shuttle Operations are subdivided between Flight Operations (principally JSC operations), Flight Hardware (principally MSFC operations) and Launch/Landing Operations (principally KSC operations). If, within the budget year, more than one million dollars is to be shifted between any of these subdivision elements, the Congress must be first notified. The Congress has 15 days to advise NASA if this action is not acceptable. Likewise, NASA must first bring to the Congress' attention any program not authorized by Congress, or any action that would substantially increase NASA's institutional capability to support Shuttle operations, change the program, or commit significant future funds. In addition, in the FY 1985 Appropriations Act (P.L. 98-371), both the Space Transportation Operations and the Space Shuttle and Production and Operational Capability budgets are capped which further constrains flexibility to reprogram funds. Thus, from a Congressional budget perspective, it is the team's judgment that since funds must be formally reprogrammed, the revised Shuttle Operations budget structure is fenced and further segregation is not needed.

In addition to revising the Congressional budget structure and establishing more rigid controls on the reallocation or reprogramming of approved funds, the management and accounting for operations costs have been steadily streamlined and simplified through contract consolidation and recompetition. Enclosures 4 and 5 show the Shuttle Operations contractor structure in 1984 and that projected in 1986, respectively. Attendant with the contractor consolidations has been a concerted effort to transition from cost plus award fee structures to cost incentive contracts that emphasize cost-effective operations. The contract form also has been structured to a task completion form as opposed to level of effort.

In 1982, many of the Shuttle contractors were engaged in both development and operations tasks which presented opportunities for cross-allocation and accounting of costs. By 1986, the

Shuttle contractors will be almost exclusively engaged in supporting operations, and any remaining development will be focused in a few specific projects, such as the Space Shuttle Main Engine (SSME). In consideration of the size of the ongoing SSME development effort, a separate SSME development project organization was created at MSFC, and separate contract schedules are maintained with the contractor to support these activities. Thus, as contractors are consolidated and development declines, Shuttle Operations becomes progressively fenced within Headquarters and at the Centers.

The R&PM budget is the principal fund source of the institutional base that supports the basic technical capability to carry out the overall NASA mission, including STS development and operation. The NASA Administrator allocates the R&PM budget to the Associate Administrators responsible for institutional management who, in turn, allocate the amounts to the Centers under their cognizance. Center Directors have discretionary control to shift manpower and resources to meet Center responsibilities for the programs assigned. Institutional resources are usually allocated to program and discipline areas to ensure adequate technical depth and breadth to manage effectively contractor involvement in both research and development activities. Historically, NASA has maintained substantial flexibility in the allocation of in-house effort to the essential requirements of changing technologies and missions. It is the team's judgment that this flexibility should be preserved and that there should be no fundamental change in the NASA institutional alignment because of Shuttle fencing operations in the near term.

Those Construction of Facility (CofF) projects that benefit Shuttle Operations are clearly identified to OMB and Congress, are justified on their individual merits, and are allocated funds by project. The allocation, control, and accountability is segregated and visible. It is the team's judgment that the CofF budget for Shuttle Operations is fenced.

Organization

At the time the NAC recommended a organization at NASA Headquarters to fence Shuttle Operations from Shuttle development programs and to establish an Administrator for Shuttle Operations at a Deputy Administrator level, the Shuttle Program was just then inaugurating operational flights. In parallel, activities to complete the basic system developments were a major program focus, and two large developments were being initiated: the Filament Wound Case Solid Rocket Motor and the Shuttle Centaur Upper Stage. With the exception of the SSME, these new development programs will be completed within the next 12 to 15 months and, with the exception of sustaining system changes principally directed to improve Shuttle's safety, turnaround, and to meet customer requirements, no new major developments are planned in the near term. In recognition of this change in balance between development and operations, the Office of Space Flight (OSF) at Headquarters is reorganizing to better focus on requirements, issues, and procedures dominant in operations, as opposed to acquisition and development. This reorganization is still in the formulation stage and is targeted to be completed early this year. In parallel with this activity, the Shuttle Operations Strategic Planning Group appointed by the Administrator and chaired by Mr. Edward Smylie is assessing future Shuttle organization designs and settings both within and outside NASA. This Group's findings and recommendations, that are to be presented to the Administrator early this year, may influence the restructured design of OSF. Accordingly, the NASA team endorses the need for and principles of the intended OSF reogranization, but offers no specific reorganization recommendation.

At the NASA Centers engaged in Shuttle Operations, each has reorganized in varying degrees since the NAC recommendation to fence operations. The objective of these reorganizations has been to consolidate and to segregate responsibilities and operations within the Centers. A comparison of the Centers' organizations in 1982 when the NAC recommendations were formulated and the Centers' organizations now are provided in Enclosures 6 and 7.

In April 1983, JSC reorganized to consolidate the six line organizations reporting to the Center Director. The objectives of this organization were: to reduce and consolidate the primary operations organizations into one group under a senior director (Director of Space Operations) in order to facilitate flight operations management, to consolidate in the Space Shuttle Projects Office all of the flight hardware and software procurement management, and to accommodate expansion of the Space Station activities at JSC. Concurrently, the Level II Space Shuttle Program Office was redesignated the NSTS Program Office to emphasize its focus on system and schedule integration in the face of increased flight demand.

In May 1983, KSC reorganized and consolidated all management responsibility for the recurring Shuttle ground processing operating under a Director for Shuttle Management and Operations. Previously, these functions had been divided between three line organizations. This change provided clear responsibility and authority at KSC to assure that the necessary changes were implemented to achieve Shuttle operations maturity.

At MSFC, all Shuttle operations are under the management of the Shuttle Projects Office. Several actions have been taken to align the organization to focus on Shuttle operations. In May 1983, an SSME Development Project Office was established at MSFC and Rocketdyne to segregate the production and flight operational activities from the continuing SSME development. In each of the MSFC Project Offices supporting mission operations, SSME, and External Tank, Solid Rocket Booster Production Management Offices were established. Also, in the Systems Management Office, a single group was established to manage the MSFC support for Vandenberg AFB operations.

In summary, it is the NASA team's judgment that the organizational steps taken at the Centers since the NAC recommendation to fence Shuttle operations provide the sought level of delineation of roles and responsibilities of managers and operators that will assure focus on the singular objective of operating the Shuttle as effectively and efficiently as possible. Hence, NASA should not disturb the Centers' Shuttle operations organizations for the foreseeable future.

Facilities

Generally, those facilities used to produce, refurbish, overhaul, test, assemble, launch, and control the Shuttle hardware are dedicated to the operations and are not available to other programs. These dedicated facilities are programmatically fenced. The maintenance and operations cost of these facilities and the manpower costs to operate them are readily identifiable and accountable. Examples of these dedicated facilities are the launch, landing, and Shuttle cargo facilities at KSC; the SSME test stands at NSTL; the production and refurbishment facilities for the External Tanks, Solid Rocket Motors and Boosters, and the SSME at the contractor plants; and the Mission Control Center, Shuttle Mission Simulators, Software Production Facility, and the Shuttle Avionics Integration Laboratory at JSC. It is estimated that more than 90 percent of Shuttle operations costs are incurred within dedicated facilities. Shuttle operations that are conducted in facilities that must be shared with other programs are generally located at JSC. The Shuttle operations share of the cost to use these facilities is normally allocated on a formulated basis relating to the work shifts used or the level of work force in the facility or the square footage of tenancy area. To replicate those portions of the shared facilities for Shuttle Operations so that these operations could be fenced would be a prohibitive cost and an inefficient use of NASA capitalized assets. Accordingly, the team believes that the budgeting, control, and accountability now in place sufficiently fences Shuttle Operations shared facilities, and no further action or segregation are warranted.

Summary

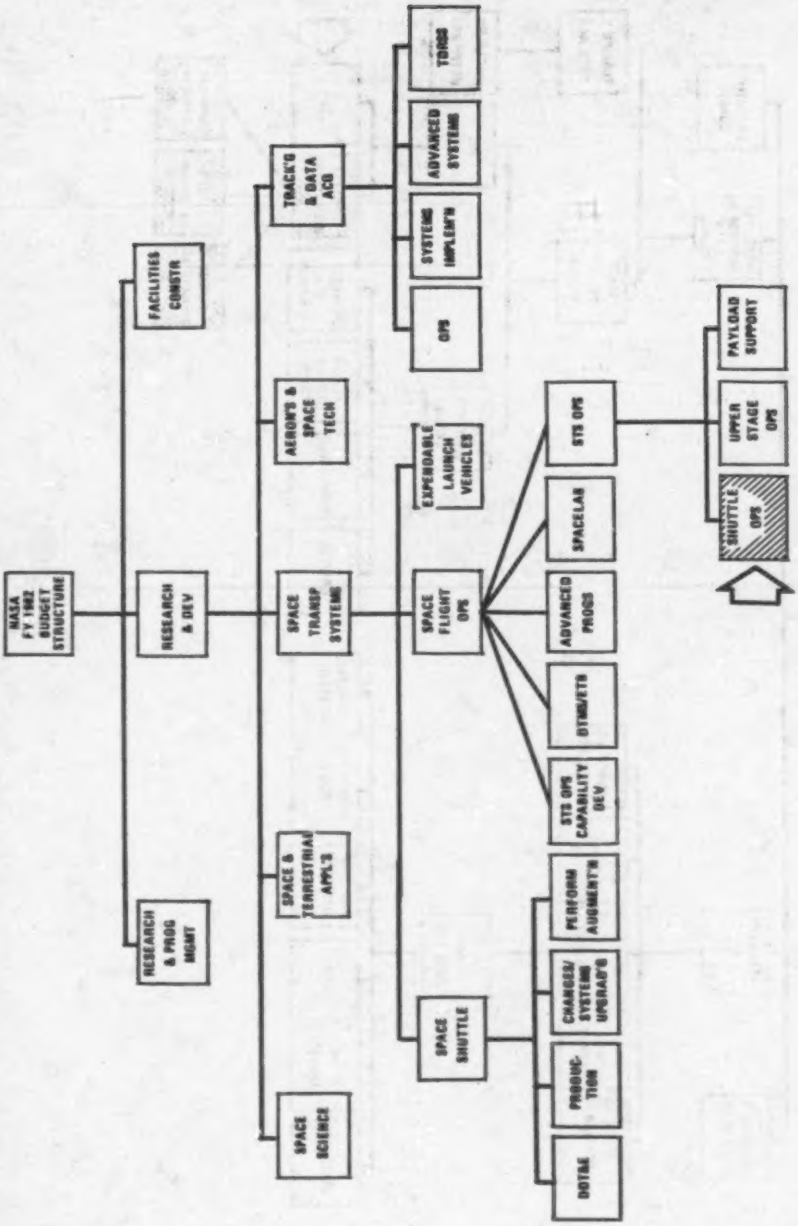
In response to the NAC recommendations, the Shuttle Operations program has all but completed the necessary actions to segregate or "fence" the program within NASA from a budget and organization perspective. The significant milestones leading to the fencing of Shuttle Operations are provided in Enclosure 8. A reorganization of Headquarters OSF in early 1985 and the consolidation at JSC of the STS operations contracts and flight equipment processing contracts by January 1986 are the last remaining milestones in the process.

SHUTTLE OPERATIONS FENCING TEAM
MEMBERSHIP

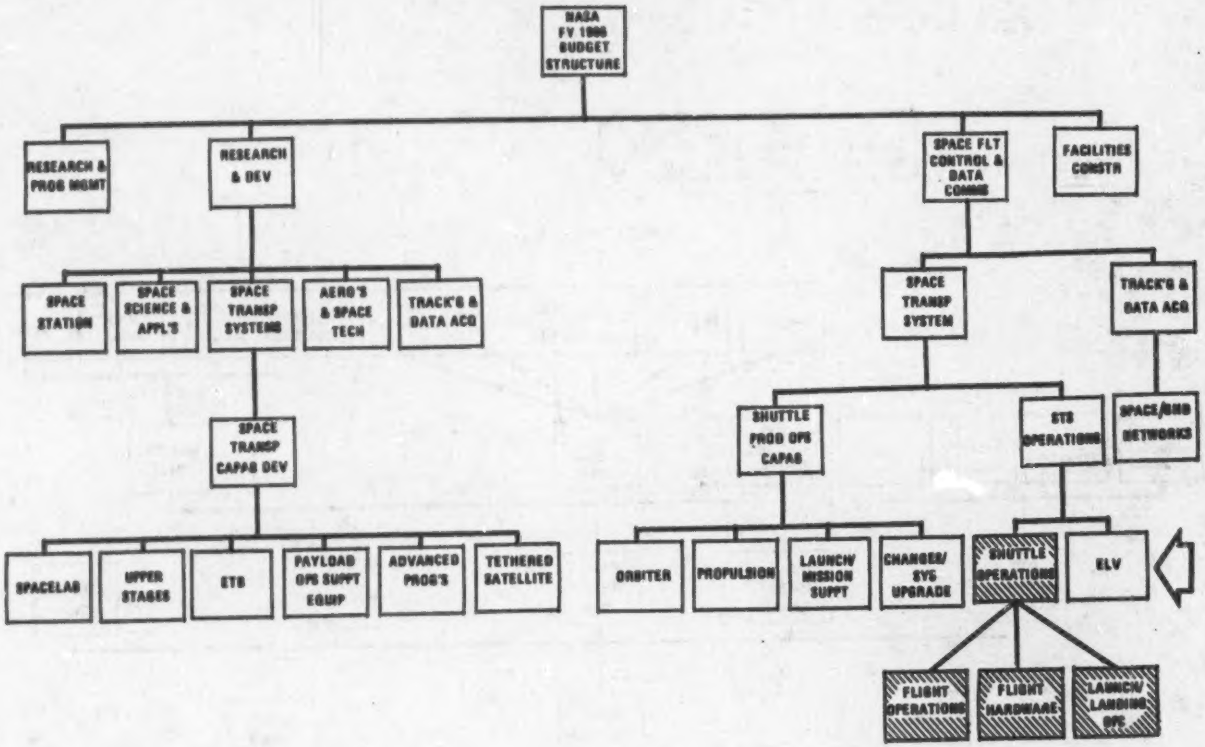
CHARLES R. GUNN CHAIRMAN, NASA HQ/DIRECTOR SHUTTLE OPS
THOMAS E. UTSMAN - KSC/DIRECTOR OF SHUTTLE MGMT & OPS
JOSEPH F. MALAGA - KSC/COMPTROLLER
JOSEPH P. LOFTUS, JR. - JSC/ASST. TO DIRECTOR, PLANS
WILLIAM C. ASKEW - MSFC/ASST. TO MGR. SHUTTLE PROJECTS
MICHAEL B. MANN - HQ/STS RESOURCE ANALYSIS BRANCH
TERRY R. MITCHELL - HQ/FLIGHT OPS

EX-OFFICIO:
ROGER LEWIS MEMBER OF SHUTTLE OPERATIONS
STRATEGIC PLANNING GROUP

ENCLOSURE 1

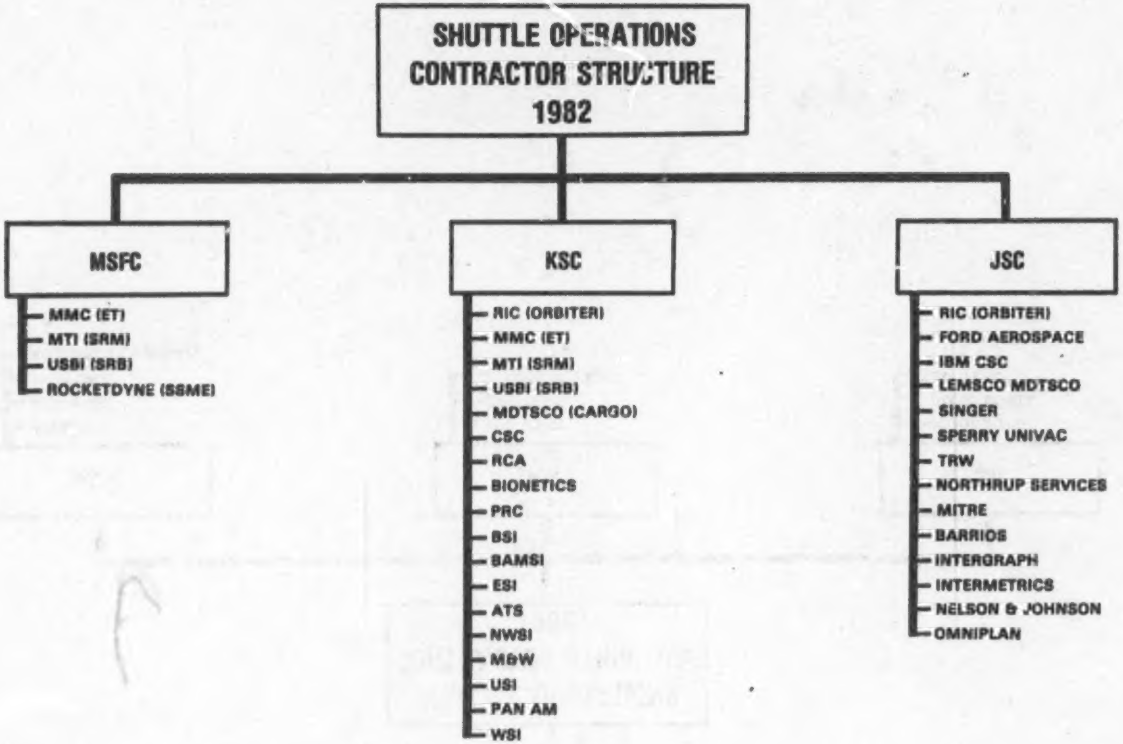

NASA FY 1982 BUDGET STRUCTURE
RESEARCH & PROG MGMT
RESEARCH & DEV
FACILITIES CONSTR
SPACE SCIENCE
SPACE & TERRESTRIAL APPL'S
SPACE TRANSP SYSTEMS
AERON'S & SPACE TECH
TRACK'G & DATA ACQ
SPACE SHUTTLE
SPACE FLIGHT OPS
EXPENDABLE LAUNCH VEHICLES
OPS
SYSTEMS IMPLEM'N
ADVANCED SYSTEMS
TDRSS
DDT&E
PRODUC-TION
CHANGES/SYSTEMS UPGRAD'G
PERFORM AUGMENT'N
STS OPS CAPABILITY DEV
DTMS/ETR
ADVANCED PROGS
SPACELAB
STS OPS
SHUTTLE OPS
UPPER STAGE OPS
PAYLOAD SUPPORT

ENCLOSURE 2


NASA
FY 1986
BUDGET
STRUCTURE
RESEARCH & PROG MGMT
RESEARCH & DEV
SPACE FLT CONTROL & DATA COMMS
FACILITIES CONSTR
SPACE STATION
SPACE SCIENCE & APPL'S
SPACE TRANSP SYSTEMS
AERO'S & SPACE TECH
TRACK'G & DATA ACQ
SPACE TRANSP CAPAB DEV
SPACELAB
UPPER STAGES
ETS
PAYLOAD OPS SUPPT EQUIP
ADVANCED PROG'S
TETHERED SATELLITE
SPACE TRANSP SYSTEM
TRACK'G & DATA ACQ
SHUTTLE PROD OPS CAPAB
STS OPERATIONS
SPACE/GND NETWORKS
ORBITER
PROPULSION
LAUNCH/ MISSION SUPPT
CHANGES/ SYS UPGRADE
SHUTTLE OPERATIONS
ELV
FLIGHT OPERATIONS
FLIGHT HARDWARE
LAUNCH/ LANDING OPS

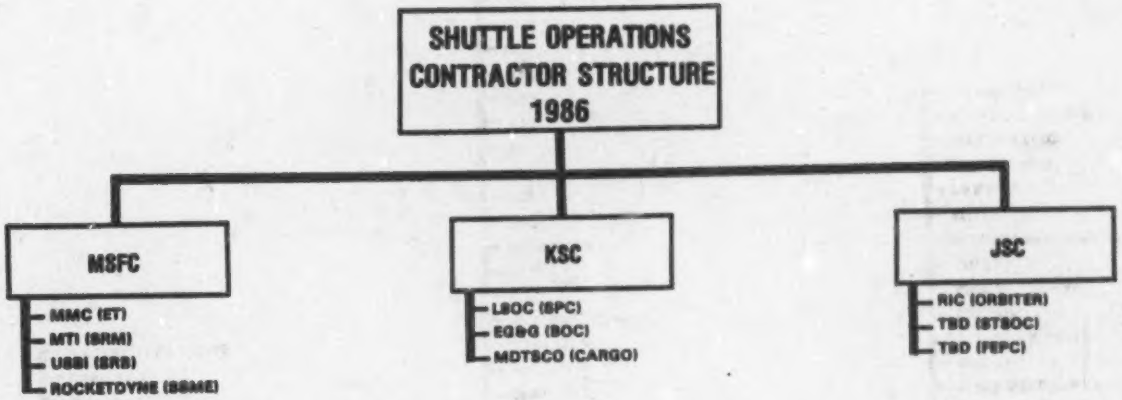
ENCLOSURE 3

M 4042 84 G


SHUTTLE OPERATIONS
CONTRACTOR STRUCTURE
1982
MSFC
MMC (ET)
MTI (SRM)
USBI (SRB)
ROCKETDYNE (SSME)
KSC
RIC (ORBITER)
MMC (ET)
MTI (SRM)
USBI (SRB)
MDTSCO (CARGO)
CSC
RCA
BIONETICS
PRC
BSI
BAMSI
ESI
ATS
NWSI
M&W
USI
PAN AM
WSI
JSC
RIC (ORBITER)
FORD AEROSPACE
IBM CSC
LEMSCO MDTSCO
SINGER
SPERRY UNIVAC
TRW
NORTHRUP SERVICES
MITRE
BARRIOS
INTERGRAPH
INTERMETRICS
NELSON & JOHNSON
OMNIPLAN

ENCLOSURE 4

M 4043 84 G



SHUTTLE OPERATIONS CONTRACTOR STRUCTURE 1986

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- MMC (ET)
- MTI (SRM)
- USBI (SRB)
- ROCKETDYNE (SSME)

KSC
- LSOC (SPC)
- EG&G (BOC)
- MDTSCO (CARGO)

JSC
- RIC (ORBITER)
- TBD (STSOC)
- TBD (FEPC)

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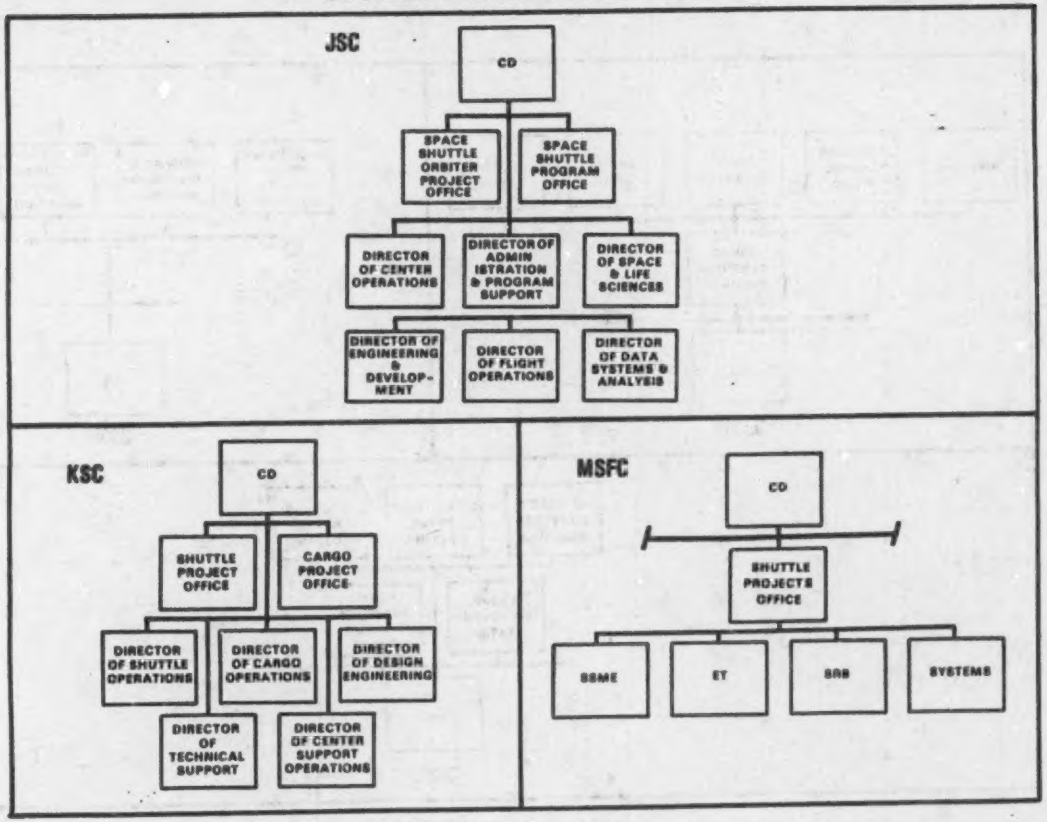
SHUTTLE ORGANIZATION — 1982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SPACE SHUTTLE PROGRAM OFFICE
DIRECTOR OF CENTER OPERATIONS
DIRECTOR OF ADMIN ISTRATION & PROGRAM SUPPORT
DIRECTOR OF SPACE & LIFE SCIENCES
DIRECTOR OF ENGINEERING & DEVELOP-MENT
DIRECTOR OF FLIGHT OPERATIONS
DIRECTOR OF DATA SYSTEMS & ANALYSIS
KSC
CD
SHUTTLE PROJECT OFFICE
CARGO PROJECT OFFICE
DIRECTOR OF SHUTTLE OPERATIONS
DIRECTOR OF CARGO OPERATIONS
DIRECTOR OF DESIGN ENGINEERING
DIRECTOR OF TECHNICAL SUPPORT
DIRECTOR OF CENTER SUPPORT OPERATIONS
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SHUTTLE PROJECTS OFFICE
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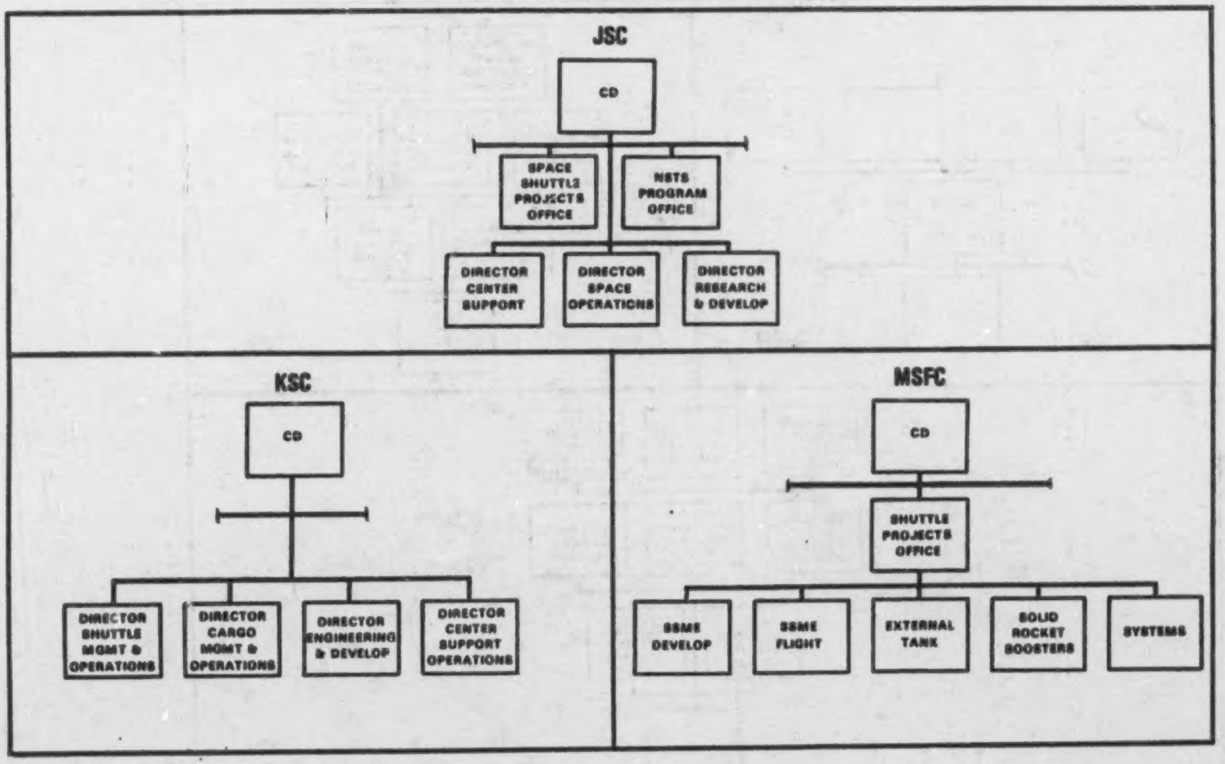
ET
SRB
SYSTEMS

ENCLOSURE 6

SHUTTLE ORGANIZATION — 1984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NSTS PROGRAM OFFICE
DIRECTOR CENTER SUPPORT
DIRECTOR SPACE OPERATIONS
DIRECTOR RESEARCH & DEVELOP
KSC
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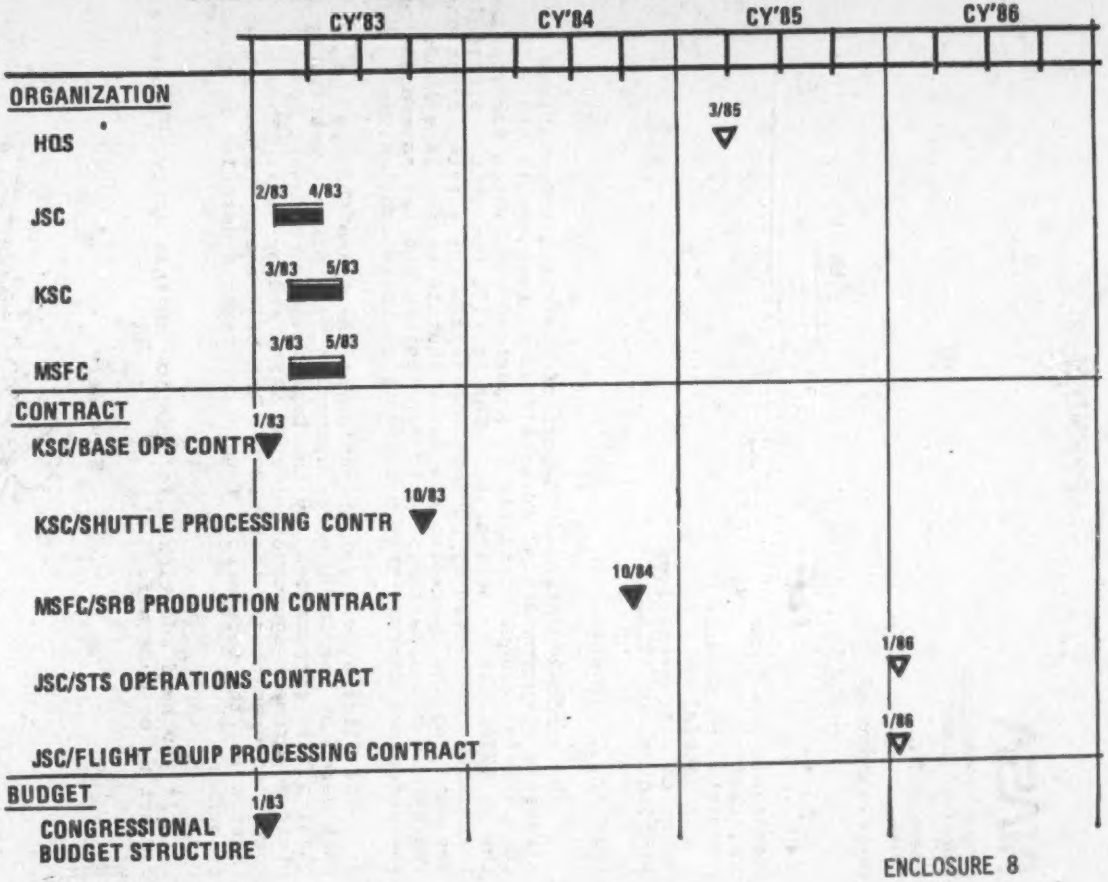
DIRECTOR SHUTTLE MGMT & OPERATIONS
DIRECTOR CARGO MGMT & OPERATIONS
DIRECTOR ENGINEERING & DEVELOP
DIRECTOR CENTER SUPPORT OPERATIONS
MSFC
CD
SHUTTLE PROJECTS OFFICE
SSME DEVELOP
SSME FLIGHT
EXTERNAL TANK
SOLID ROCKET BOOSTERS
SYSTEMS

ENCLOSURE 7

SHUTTLE OPERATIONS RESTRUCTURES



ENCLOSURE 8

APPENDIX 13

NASA
National Aeronautics and
Space Administration
Washington, D.C.
20546
Office of the Administrator

MAR 11 1985

Honorable Don Fuqua
Chairman
Committee on Science
and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

The enclosed document "Report of the Shuttle Operations Strategic Planning Group" is submitted in response to the Committee's request contained in Report 98-629, which accompanied the FY 1985 NASA Authorization. The Shuttle Operations Strategic Planning Group headed by Ed Smylie assessed the strategic options for managing and operating the Space Shuttle in the late 1980s. The report contains the Group's conclusions and its assessment of the principal factors that brought it to those conclusions.

The alternatives for operation of the Space Shuttle considered by the Group were; operation by a private entity, by a quasi-public corporation, by the Department of Defense, by a civil government agency other than NASA, and by NASA. They concluded unaminously that NASA is the best agency to operate the Shuttle for the foreseeable future for reasons detailed in the report.

If you need additional information on this activity, please contact me or my staff.

Sincerely,

James M. Beggs
Administrator

Enclosure

cc:
Honorable Manuel Lujan, Jr.

March 7, 1985

Report of the Shuttle Operations Strategic Planning Group

NASA
National
Aeronautics and
Space
Administration

REPORT OF THE SHUTTLE OPERATIONS
STRATEGIC PLANNING GROUP

March 7, 1985

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REPORT OF THE SHUTTLE OPERATIONS
STRATEGIC PLANNING GROUP

I. Executive Summary

The Shuttle Operations Strategic Planning Group, at the request of the NASA Administrator, has assessed the strategic options for managing and operating the Space Shuttle in the late 1980s, with emphasis on the institutional setting for Space Shuttle operations. The Group examined key elements of NASA's charter, relevant aspects of the legislative history of the Shuttle, the present and projected future status of the Shuttle, the environment in which it operates, and the NASA mode of operation. Particular attention was given to the requirements for the Shuttle established by the Department of Defense and to the special relationships that have been developed between NASA and the DOD.

Key findings of the Group are that:

- The Space Shuttle is a vital and unique national asset, both as a symbol of U. S. imagination and enterprise and for a variety of highly complex missions it performs in support of national security, civil government, and commercial space programs.
- The Space Shuttle is the primary means for NASA access to space to perform its mission in the conduct of space exploration.
- The DOD is committed to the use of the Shuttle for important national security missions and has established major facilities of its own which complement those of NASA.
- The DOD requirements will continue to have the highest priority.
- The Shuttle system will meet its capability requirements as planned by the late 1980s. At the same time, more demanding tasks will emerge to expand the utilization of the system.
- The Shuttle system is capable of supporting the planned rate of 24 flights per year, but significant additional investment would be required to achieve a flight rate of 30 flights per year on a sustained basis.
- Because high priority is being placed on attracting customers to the Shuttle in order to foster the commercial use of space, Shuttle pricing must take into consideration this objective.

The Group concludes that:

A. Private operation of the Shuttle in the foreseeable future is not viable because:

- o The Shuttle's use as an important instrument of national policy is inconsistent with private operation.
- o Without a major new use, private operation cannot be both economically beneficial to the government and commercially viable.
- o DOD requirements mandate government control.
- o Private operation would inhibit the commercial development of new products and processes.
- o A private operator could not relieve the government of its liability responsibilities.

B. Operation of the Shuttle by a quasi-public corporation in the foreseeable future is not desirable because:

- o The program would not have sufficient non-government income potential to enable it to finance either acquisition or operations without reliance on government guarantees and appropriated funds.
- o The freedom to exercise marketing initiatives sometimes available to quasi-public corporations would be constrained by government dominance of the use of the Shuttle.

C. Operation of the Shuttle by the DOD is not desirable because:

- o The U.S. policy regarding peaceful exploration and use of space would be perceived to be changing.
- o Operation of the Shuttle would have to compete with many high priority demands on DOD's resources.
- o Potential customers, both foreign and domestic, would be uneasy and perhaps inhibited.
- o DOD does not appear to want this responsibility; their mission does not include providing service for the range of current and prospective Shuttle users; and they may well resist such an assignment.

D. Operation of the Shuttle by another civil organization of the government is not desirable because:

- o No other organization has the expertise to operate the Shuttle, and costs to develop that expertise are prohibitive.

- The Shuttle is needed for tasks and missions that NASA is best suited to support--space science, space applications, and space technology development.
- Establishing a capability to operate the Shuttle in another government agency would result in a significant transition expense and would lead to extensive duplication of personnel. Alternatively, transferring the NASA personnel and facilities to another agency would strain NASA's ability to perform its mission.
- The operation would be more complex in that it would involve new operational and organizational interfaces between the new agency and the DOD, NASA, and the commercial customers.

E. NASA is the best agency to operate the Shuttle in the foreseeable future because:

- NASA's mission to conduct space exploration, including space science, space applications, space technology, and space station programs, depends upon the Shuttle.
- NASA has the required engineering, management, launch, and mission operations capability.

There are no inherent reasons why NASA cannot achieve optimum operation of Shuttle and effectively perform its overall research and development mission. As the Shuttle evolves and the flight rate increases, organizational realignments within NASA will become necessary to ensure that NASA's research and development and Shuttle operations do not detract from one another, but are mutually supportive. The goal of any such realignment should be to establish clear lines of operational responsibility, authority, and accountability. The Group believes the development of this realignment to be a line management function.

II. Purpose of Study and Charter

April 12, 1981, saw the first orbital flight of the Space Shuttle, highlighting a 10-year development and opening a new era of ready access to space. At this writing, three of the four Orbiters authorized by the Congress have been delivered and have seen service (a total of 15 missions), and the fourth Orbiter is scheduled to be delivered in mid 1985. Although it has encountered problems, as have most high-technology newly-developed systems, the Space Shuttle has demonstrated great versatility in the launch and deployment of satellites, conduct of research in the space environment, (in the cabin, in the pressurized Spacelab module, and in a host of open payload bay systems), repair of satellites in orbit, and retrieval for reuse of communications satellites which failed to reach necessary orbit altitudes. Activities have included research by the National Aeronautics and Space Administration, the European Space Agency (ESA), commercial entities, and others; national security missions for the Department of Defense (DOD); and launch of commercial communications satellites.

With Space Shuttle operations now approaching a frequency of one each month, the NASA Administrator felt it was timely to assess the many factors involved and the various proposals for operation and management of the Space Shuttle program so that he can take any steps necessary to make those operations most effective. On July 31, 1984, during the course of Hearings on Space Shuttle Requirements, Operations, and Future Plans before the Subcommittee on Space Science and Applications, Committee on Science and Technology, U.S. House of Representatives, Administrator Beggs announced that he would establish the Shuttle Operations Strategic Planning Group to assess the many operations alternatives. The Group was established on August 16, 1984, with a charter to "provide and assess strategic options for managing and operating the Space Shuttle in the late 1980s and beyond which defines the transition steps and milestones, if any, and the institutional setting for Space Shuttle operations." The full charter of the Group, its membership, and a summary of the workplan followed are given in Appendix I. This report represents the Group's report to the Administrator.

III. Scope of Inquiry

The Planning Group investigated a broad variety of factors relevant to the issues addressed by the study. Those factors identified during fact finding and the Group's deliberations which are most pertinent to the issues are described in the following sections:

A. NASA Mission

Any consideration of the organization and management of Shuttle operations must begin with the mission of the system's developer and present operator, NASA. The charter of NASA is provided by the National Aeronautics and Space Act of 1958, as amended, pertinent excerpts of which are included in Appendix II. Of particular interest to the issues under consideration is that NASA is authorized to conduct "aeronautical and space activities", defined in Sec. 103(1) to include (by amendments in the Fiscal Year 1984 Authorization Act) the subparagraph (C), "the operation of a space transportation system including the Space Shuttle, upper stages, space platforms, and related equipment." Prior to this amendment, NASA considered it had authority to operate space systems under Sec. 102(1) as it then stood without that addition, but the authority conferred by the addition is certainly unambiguous. Also added more recently by the Fiscal Year (FY) 1985 Authorization Act is the authority for NASA to "seek and encourage, to the maximum extent possible, the fullest commercial use of space."

Appendix II also provides a summary of current national space policy as it applies to the Space Transportation System (STS). Basic policy with respect to the STS, as stated by the President on July 4, 1982, is:

- The STS is the primary space launch system for both national security and civil government missions; its capabilities shall be available to authorized users--domestic and foreign, commercial and governmental. Government spacecraft should be designed for the STS and transition to the Shuttle should occur as expeditiously as practical.
- The first priority of the STS program is to make the system fully operational and cost-effective in providing routine access to space. Development will be continued through NASA in cooperation with DOD. Enhancement of capability should be pursued as national requirements are defined.
- For the near term, the STS will continue to be managed and operated consistent with the current NASA/DOD Memoranda of Understanding. As STS operations mature, flexibility to transition to a different institutional structure will be maintained.

- Expendable launch vehicle (ELV) operations shall be continued by the U.S. government until the capabilities of the STS are sufficient to meet government needs and obligations.

On May 16, 1983, the President announced a policy to facilitate commercial operations of ELVs, including making available, on a reimbursable basis, facilities, equipment, and services to support production and operation of commercial ELVs. This announcement also signaled the government's intent to establish a policy of full cost recovery for commercial and foreign STS flight operations after 1988. In a later decision (February 24, 1984), the President designated the Department of Transportation as the lead agency to encourage and facilitate commercial ELV activities by the U.S. private sector.

Government support for commercial space activities was extended from ELVs to the full range of endeavors in the President's policy statement of July 20, 1984. This statement affirmed the government's intent to encourage private sector space activities and outlined initiatives to ensure that such activities are not hampered by out-of-date laws, regulations, and policies.

On August 15, 1984, the President approved a National Space Strategy which reaffirmed the nation's commitments to the STS program and charged NASA and DOD with joint preparation of a report to define "a fully operational and cost-effective STS" and to specify the steps leading to that status. NASA was further charged with developing a time-phased plan for implementing full cost recovery for commercial and foreign STS flight operations occurring after October 1, 1988, by which date the STS would be "fully operational." The Office of Management and Budget (OMB) and other involved agencies were charged with an assessment of international competitiveness of both U.S. commercial ELVs and the STS.

That strategy was augmented on February 25, 1985, by a National Security Launch Strategy. The key elements include agreement that the Air Force will procure 10 expendable launch vehicles for use at a rate of about 2 per year from 1988 through 1992, commitment by the DOD to at least one-third of the STS flights during the next 10 years at a price (to be determined) that provides a positive incentive, and joint DOD/NASA study of a second-generation space transportation system.

These foregoing elements define the policy environment established by the present Administration and in which the present assessment of future possibilities for management of Shuttle operations is being conducted. The STS is considered the primary launch system for government space missions and is available for authorized users. NASA has adequate authority to conduct STS operations, but operation by other entities is not precluded and could be mandated by statute, as was operation of communications satellites (Comsat Act).

B. Legislative History of Shuttle

As the Apollo program was approaching achievement of the first manned lunar landing, studies of the post-Apollo space program were underway by NASA and other groups. There was general agreement among the study groups that development of a manned space station would be a central element of most any program of manned exploration or extended occupancy of space. Equally evident was the requirement for a transportation system for construction, resupply, and crew rotation in support of the space station.

During the study phases, the transportation system concept evolved into a fully reusable concept and became known as the Space Shuttle. As planning progressed, it became evident that the reduced space program funding levels likely in the 1970s would not permit simultaneous development of both space station and transportation system. Attention then focused on the Space Shuttle, which had the capabilities to: (1) launch and recover orbital payloads, (2) provide a platform for space research and development (R&D), and (3) provide for the next steps in manned space flight.

Debate within the Administration and the Congress was quite intense in 1970 and 1971 as elements of the Space Shuttle came under discussion. Debate involved all three of the listed attributes of a reusable launch system, with much attention given to the economics of the Shuttle vs. ELVs as a launch system and to the importance of maintaining a vigorous manned space flight program. The details of these debates are not repeated here, but it can be concluded from more recent studies[1,2] that the principal motivation among the Space Shuttle's supporters in the Congress was to maintain a post-Apollo manned space flight capability, and that projected launch service cost savings, although important, were not an overriding factor.

C. Summary of Prior Studies

There have been a number of studies (see Appendix III) on the future operation of the Space Shuttle. Typical of the results of the studies are the following conclusions:

---

[1] -----, United States Civilian Space Programs, 1958-1978, Report prepared for the Subcommittee on Space Science and Applications of the Committee on Science and Technology, U.S. House of Representatives (97th Congress, First Session), by the Science Policy Research Division, Congressional Research Service, Library of Congress, U.S. Government Printing Office, Washington, 1981, pp. 445-457.

[2] Hechler, Ken, Toward the Endless Frontier - History of the Committee on Science and Technology, 1959-79, Committee Print, U.S. House of Representatives, U.S. Government Printing Office, Washington, 1980, pp. 269-305.

Study	Conclusion
Aerospace Corp. (1976)	o NASA management with prime contractor as operator
National Academy of Public Administration (1977)	o Federal ownership and managed by NASA
Gillam (1982)	o Maintain current management policy but proceed toward Aerospace Corp. recommendation
Office of Technology Assessment (1982)	o No definitive recommendation
Huberman (1982)	o Retain STS operations in NASA until a better long-term option becomes evident
NASA (1982)	o Maintain current NASA/DOD management for both near and long term
NASA Advisory Council (1983)	o Retain in NASA but with fenced manpower, finances and facilities o Consider contracting out market development activities

The key factors considered by most of the prior studies in reaching these conclusions were: (1) the definition and expectation of when the Shuttle will be operational; (2) the extent of government vs. commercial demand; (3) the feasibility of a significant return on investment; and (4) the likelihood of Congressional support for transferring the Shuttle to another operator.

The common conclusions of most of the studies were that: (1) the Shuttle is still in development status; (2) the Shuttle must remain in NASA for technological support; (3) the government is the principal user; and (4) there will be an increase in civil sector space activities, primarily in the private sector. A question addressed in the present assessment is whether these conclusions are still valid.

D. The Space Shuttle Today and Tomorrow

The ability of any future institution to operate the Shuttle successfully would be very much dependent upon the systems, the people, and the environmental factors in which the operations are conducted. Preparatory to assessing the alternatives--and to help determine if the conclusions from the prior studies were still valid--the Group reviewed the current status and trends that would indicate the status of the Shuttle in five to ten years. The Shuttle vehicle and facilities, personnel and procedures, and market development and pricing were considered.

1. The Shuttle Vehicle

Critical to the assessment of the ability to transfer Shuttle operations to another organization is the status of the vehicle and associated systems. The Orbiter is presently in the transition phase from R&D to achieving its full capabilities by the late 1980s. By then, planned system upgrades should be completed. As with any system employing advanced technology, problems have been encountered during the transition. Such problems are expected to arise without undue impact on future Shuttle operations.

The Space Shuttle Main Engines are entering the operational phase. The critical development item remaining is to achieve sufficient operating margins and life. It is anticipated that the presently identified improvements to satisfy these requirements will be incorporated into the fleet in the late 1980s to early 1990s.

The External Tank and Solid Rocket Booster, in their current designs, are considered operational now. It is anticipated that the upgraded Solid Rocket Booster with the filament wound case will be qualified for flight by 1986 and certified as operational by the late 1980s.

2. Facilities

The ability to conduct launch, flight, recovery, and turnaround operations hinges upon the capabilities of the ground facilities. These facilities represent a multi-billion dollar capital investment. To illustrate, the NASA facilities include:

- Refurbishment, Checkout and Launch of Shuttle (Kennedy Space Center - KSC) - Orbiter, External Tank, and Solid Rocket Booster processing facilities, Vehicle Assembly Building, mobile launch platforms and crawler transporters for stacking and transporting the vehicle to the launch pad, and launch pads and launch control center for final checkout and launch.
- Payload Handling (KSC) - vertical and horizontal processing facilities for payload checkout and installation in required transporters.
- Landing Operations - Shuttle landing facilities at KSC and Edwards Air Force Base, including the deservicing and carrier mounting facilities; contingency landing sites and necessary equipment.

- Mission Planning and Operations (Johnson Space Center - JSC) - crew training facilities, crew equipment processing facilities, Mission Control Center, and supporting facilities.
- Sustaining Engineering Support (JSC, KSC, Marshall Space Flight Center - MSFC) - extensive laboratories to support the functions.

The Air Force also has a substantial investment in facilities to support like functions which are complementary to the NASA investment but capable of providing polar orbits. They include:

- Refurbishment, Checkout, and Launch of Shuttle (Vandenberg Air Force Base - VAFB) - Orbiter, External Tank, and Solid Rocket Booster processing facilities, Space Launch Complex 6 (where the vehicle is stacked and launched), and the Launch Operations Control Center.
- Payload Handling (VAFB) - in the Orbiter processing facility and the payload integration structure at the pad.
- Landing Operations (VAFB) - The Shuttle landing facilities.
- Mission Planning and Operations (Colorado Springs) - That portion of the Consolidated Space Operations Center dedicated to Shuttle operations, as well as dedicated mission and data handling facilities at JSC.
- Sustaining Engineering Support (Space Division) - For unique Air Force facilities.

These facilities in being and under construction for operation within the next couple of years will provide the capability to handle 24 missions per year. Achievement of a flight rate of 30 per year on a sustained basis would require significant investment in additional facilities.

3. Personnel and Procedures

In addition to the flight hardware and facilities, the government contractor teams (NASA and Air Force) are an invaluable asset to the Space Shuttle program. The government personnel with their contractor teams manage and execute the daily responsibilities of program management, sustaining and system engineering, flight operations, flight software, customer integration, procurement of the propulsion elements, launch operations, ground software, cargo processing, etc. They manage and perform all of the necessary disciplines and activities to exercise the required control of all activities from daily operations through long-range planning and budgeting. These teams operate in a programmatic structure with very well understood assignments and limits of responsibilities and very many procedures (formal and informal) for the conduct of business. The Configuration Control Boards and other operating mechanisms are the visible features of this communication, command, and control system. This team, with its understanding of the job and its operating procedures, is in place and functioning smoothly.

4. Market Projection (Appendix IV)

Critical to the consideration of any commercial operation of the Shuttle, and important to the operation in any non-commercial mode, is a projection of the market for the launch services offered by the Shuttle. A national STS traffic model has been developed by NASA. That model, totalling 24 flights per year, is estimated, for the 3 years beginning in 1989, as:

NATIONAL STS TRAFFIC MODEL

CUSTOMER	1989	1990	1991
NASA	6.8	9.3	8.3
COMMERCIAL & FOREIGN	2.0	4.2	4.2
DOD	13.8	9.2	10.2
REFLIGHT OPPORTUNITY	1.4	1.3	1.3
STS MODEL	24	24	24

Assessments of the demand projected beyond this period are, of necessity, somewhat tenuous. The uncertainties include:

- The growth of the communication satellite market, in view of the current glut of transponder capability and the uncertain development of the direct broadcast satellite market.
- New market development, which may depend on materials processing. Understanding of the phenomenology of processes in the space environment needs to be completed in order that industrial researchers can assess and develop the market potential.
- The impact of competition from the expendable launch vehicles, domestic and foreign.
- The demand generated by space station, which is estimated to be on the order of five Shuttle flights a year in the 1990s.
- The demands of the DOD's Strategic Defense Initiative as it enters the test and prototype development phase.

o Shuttle pricing policy

Because of these uncertainties, it would be imprudent to plan now for flight rates in excess of 24 per year. Even with such a flight rate, the government is expected to be the dominant user.

5. Pricing (Appendix IV)

A prime determinant of market demand, especially for non-government markets, is price. NASA has developed a cost model for the post-1988 period that will permit the establishment of prices for various users, depending on the pricing policy that applies. The cost, based on the traffic model of 24 flights per year, includes all direct and indirect costs as well as allocation of institutional support costs associated with Space Shuttle operations. Excluded are recoupment of sunk costs for Space Shuttle research and development and amortization of the Shuttle Orbiters. On this basis, the projected cost per flight (in millions of FY 1982 dollars) is:

	FY 1989	FY 1990	FY 1991	Average
Cost per Flight	83.9	83.6	82.5	83.3

These figures compare to the expected out-of-pocket cost for the FY 1986-1988 time period of $71 million (also in FY 1982 dollars). Pricing policy at the present time includes full recovery of operating costs for foreign and commercial launches in the post-1988 period and provides for reduced rates for access to space on the Shuttle for the flight of R&D experiments to stimulate the commercial use of space.

E. NASA Operating Mode

To deal with organizational proposals, it is vital to understand how the space transportation centers of NASA work. The Center Director role is one of technical oversight and accountability to Headquarters for the work at his respective institution. The Center Director and his local organization also provide for the promotion, advancement, allocation, and overall care of all of the center employees. The Center Directors, then, are responsible to the Associate Administrator for Space Flight at Headquarters for STS efforts at their centers. The respective program and line management personnel derive their authority and operate under the auspices of the Center Director.

In addition to this structure, there is also an intercenter programmatic structure to handle the daily interactions required within this integrated system of machines and personnel called the STS. Headquarters has delegated the program management office at JSC as the lead office for the Shuttle program. This is the programmatic channel for formal interactions between Headquarters and all Shuttle center elements. Within dollar, schedule, and responsibility constraints, this office serves to integrate the efforts of the various elements at the three centers, and to conduct the Configuration Control Board activities.

F. Market Environment: Present and Projected

Future operations of the Space Shuttle will clearly be significantly affected by the market environment in which those operations take place. The diversity of users and constituencies with their conflicting objectives and interests means the Space Shuttle is, for the time being, both a transporter and a national research capability. On the one hand, commercial communication satellite customers are looking for inexpensive transportation and a highly reliable schedule. On the other hand, researchers within government, scientific, and industrial research communities are looking for a range of ground and orbital services that require flexibility and are seldom routine. There also is a growing demand for orbital services for the large space facilities such as orbiting telescopes, as well as for servicing science, applications, and conceivably space manufacturing platforms. As NASA's current market projections indicate, the market is reasonably divided between them.

With the approval by the Congress of development of a space station to be operating in the 1990s, the Shuttle will be employed more and more in a mode taking advantage of its abilities to remain on orbit for 7 to 10 days in its present configuration. This trend is symptomatic of the larger transition in space activities from satellite launch activities of short duration to space operations missions of longer duration. Examples of the latter are Shuttle missions in support of orbiting facilities such as the Hubble Space Telescope and on-board facilities such as Spacelab. Development of techniques for space station operations will undoubtedly accelerate this trend and the Shuttle will be a major contributor. Further, if commercial use of space facilities is developed, the Shuttle will serve as a critical element of that development toward eventual space station association. Clearly, the Shuttle must be thought of not only as a launch, orbital operations, and return vehicle in its own right, but as part of the total orbital space infrastructure of the 1990s, including a space station and possibly other space elements.

As to launch service competition, the Shuttle will continue to face stiff competition from the French expendable launch vehicle, Ariane, for the commercial communications satellite market. It is conceivable that privatized ELVs could also become significant competitors. Market competition from Japan, the Soviet Union, and others is also likely to emerge.

G. Special Character of the NASA/DOD Relationship

Operations of the Shuttle are critically dependent upon the interdependence of NASA and the DOD. The basis for the relationship is defined in a NASA/DOD Memorandum of Understanding that has existed since 1977. The NASA/DOD relationship is characterized by several unique arrangements that have existed between the two organizations throughout the Shuttle development. Historically, NASA and DOD have a relationship that has grown out of the development of launch vehicle boosters in which both have engaged. Also, very early in the program, NASA and DOD agreed that some segments of the STS would be developed by NASA and some by DOD.

The Air Force is responsible for building and operating the Vandenberg Air Force Base Shuttle launch and landing site. As such, the Air Force will be responsible for the launch, landing, and servicing of Shuttle vehicles at Vandenberg. This site will be used primarily, but not exclusively, for national security payloads. The Vandenberg site will be characterized by a relatively low flight rate, but a number of the flights will stress Shuttle payload lift capability and the payloads will be of relatively high cost. This Air Force development will represent a capital investment exceeding $8 billion. The effort has sustained a high budget and schedule priority, demonstrating clear USAF commitment to the Shuttle program. The Air Force is developing the Shuttle Operational Planning Complex (SOPC) as part of its Consolidated Space Operations Center (CSOC). This Complex will be an adjunct to the mission planning and control capabilities of the Johnson Space Center. Each flight will still depend on JSC for critical portions of mission planning development. The SOPC will, however, offer more control of classified portions of flights and it can serve in some cases as a backup to JSC in the event of an emergency or catastrophe.

The Air Force has been responsible for development and procurement of the Inertial Upper Stage for use by both DOD and NASA. This development has been followed by a joint development of the Centaur upper stage to use with the Shuttle. In the accomplishment of the above developments, personnel have been exchanged to further the joint nature of the developments.

There are many unique aspects of the NASA/DOD Shuttle relationship that have evolved because of the interdependence of the two programs. Included are:

- DOD is the only organization other than NASA that will have the facilities and the ability to launch, recover, and service Shuttle vehicles.
- DOD and NASA have established mechanisms to try to maximize Shuttle program efficiency by joint scheduling of all Shuttle activities.
- The importance of DOD launches to national security has led to an arrangement whereby DOD can exercise schedule priority for Shuttle launches.

- Joint efforts have been undertaken to protect those Shuttle flight aspects that require special security protection.

- NASA and DOD have an agreed-upon pricing policy, based upon a quid pro quo relationship, that applies to current DOD Shuttle flights. The two agencies will jointly develop a pricing policy for the next 10 years during which period DOD has committed to the use of at least one-third of the STS flights.

IV. Basis for Assessment

Assessment of the various alternatives for long term operation and management of the Space Shuttle is dependent, to a large degree, upon the conditions under which those operations take place. As a result of its studies to date, the Group has identified a reference set of conditions in which the Shuttle is assumed to operate in the time period of 5 to 10 years from now. These conditions, derived from the Group's fact finding, have been employed as the reference for the assessments which follow. They are summarized as follows:

A. National and NASA Policies

National space policy (Appendix II) will apply for the full period in question. Accordingly, the STS will continue to be the primary launch system for both U.S. national security and civil government needs, and the Shuttle's utility to civil users will continue to be assured. Further, the U.S. Government will continue to encourage and facilitate commercial expendable launch vehicle operations.

As the Nation's principal space launch vehicle for both government and private sector payloads, the STS will retain its dual nature. It will serve both as a space transportation system, providing delivery, orbital servicing, and return services of satellite systems; and as a valuable national resource to support important national objectives, political, national security, and research and development, with special emphasis on the capabilities offered by having man in space.

Pricing policy will be aligned to these purposes. The price proposed for commercial and foreign Space Shuttle flights will be fixed so as to recover the full costs of operating the system. To continue the Administration initiative to foster the commercial use of space, the operator will provide appropriate reduced rates for commercial research and development payloads that can stimulate space-based businesses. As new industries mature and enter into full-scale space production, they will be charged on the basis of full recovery of operating costs.

B. Market Development and Flight Rate

The requirement for Shuttle services is assumed to grow as projected by the NASA cost model (Appendix IV). Growth is sufficient to reach a Shuttle flight rate of 24 per year by FY 1989 (20 from KSC and 4 from VAFB). This rate is assumed to continue through the mid 1990s. The uncertainties in this include the possibility of missions specifically in support of the Strategic Defense Initiative and changes to present estimates of space station usage. This estimated flight rate also assumes that the Shuttle retains its share of the market for delivery of satellites to orbit.

C. Cost

Costs per flight for a 24 per year flight rate are assumed, as projected by the NASA cost model (Appendix IV), at a level of about $83 million (1982 dollars) for the period beginning in FY 1989.

D. Competition

U.S. ELVs would be provided by commercial entities competing with the Shuttle and foreign ELVs for launch service business. Foreign ELVs will continue to receive some support from their respective governments. The Ariane will be a significant competitor. Competition from foreign and domestic ELVs could constrain the Shuttle flight rate below 24 per year.

The Space Shuttle has no real competition for payloads requiring operation and/or servicing on orbit and return to Earth, unless the Soviet Union chooses to make their expected shuttle-type vehicle available for such purposes. (France has now announced plans to pursue the development of a small shuttle-type vehicle.)

In the early 1990s, the U.S. space station is expected to expand the on-orbit capabilities offered by the Shuttle.

E. Systems Capabilities and Operations

By late 1988, the Space Shuttle is planned to be fully operational. In summary, this means that it is ready and available for routine use in the intended operational environment to achieve the committed operational objectives. Specifically, (1) critical performance capabilities will have been verified by flight demonstration; (2) adequate logistic support for the system will be in place; (3) the ground and flight processing capabilities will be adequate to support the committed flight schedule of up to 24 flights per year with margins for routine contingencies attendant with a flight surge capability; (4) and the appropriate operational management capabilities will be in place.

F. DOD Considerations

The Shuttle working relationships developed between NASA and the DOD over the years will continue as defined by the provisions of the Memorandum of Understanding. The Shuttle will continue to be the principal vehicle for DOD purposes; DOD usage will account for at least one-third of the STS missions for the next 10 years.

V. Discussion

During the reviews, briefings, tours, and discussions that the Group conducted during the course of the study (see Appendix I), the members became convinced that the Shuttle program possesses characteristics that set it apart from previous space endeavors or any other large-scale technical project. Taken together, they lead the group to the conclusions of Section VII.

A. Special Characteristics

To assess the best management structure for the Shuttle, it is important to understand some special characteristics of the Shuttle that must be considered in addition to its normal characteristics as a transportation system.

- First, the Shuttle is a reusable, manned vehicle and only four Orbiters exist. By national policy, it is the primary launch system for both U.S. national security and civil government needs.
- Second, the total Shuttle investment by NASA and the DOD is more than $20 billion.
- Third, the Shuttle serves as a research and development facility in space.
- Fourth, because there are only four Orbiters, concepts such as "production lines" and "fleets" in the sense employed in most other transportation modes don't apply. Furthermore, many Shuttle flights now require customer-specific optimization of the vehicle.

For these and many other reasons, making analogies between the Shuttle program and programs such as those with current expendable launch vehicles or aircraft can be misleading.

B. Variety of Users

The Shuttle serves many customers, each with different interests, priorities, and requirements.

- The DOD - Because of the importance of its payloads to national security, the DOD receives first priority for launch opportunities, the right to preempt other payloads for launch, and a launch-on-demand priority. It is important that definite prices be specified with sufficient lead time so DOD can accomplish orderly planning and budgeting for its Shuttle use. It is also important that the Shuttle launch schedule remain stable because of the DOD need to meet its requirements for launch dates for national security payloads. For some missions, the DOD will need a Shuttle lift capability for payloads that exceed the capability of current expendable launch vehicles. Shuttle developments are underway to meet these DOD requirements. The DOD plans to use the Shuttle to conduct R&D in the space environment and to utilize man's presence in space to advantage.

- Civil U.S. Government - For this class of payload or mission, some of the unique features of the Shuttle become important. Many of the large facility-type scientific satellites are specifically designed to be serviced by the Shuttle. A prime example is the Hubble Space Telescope, to be launched in 1986, which can only be launched by the Shuttle and depends on the Shuttle for instrument replacement on orbit, possible repair and refurbishment on orbit, and eventually return to Earth for complete refurbishment and relaunch. For this kind of operation, the presence of man is crucial for success. With the successes of the Solar Maximum Mission repair in April 1984 and the recovery of the Westar and Palapa communications satellites in November 1984, it is likely that this use of the Shuttle capability will expand to most other users.

  Another civil U. S. and foreign government use of Shuttle is to carry out scientific investigations in and from the Shuttle. The prime example of these types of missions are those involving the ESA-developed Spacelab. These missions are typified by extended stay time on orbit, a customized, highly integrated mission timeline, and special requirements and services from the Orbiter. Again, man's presence is crucial for conduct of this type of mission.

- Foreign Government - These missions have many of the same characteristics of the civil U.S. Government missions except that, to date, no satellites require the payload weight capability of the Shuttle, and foreign governments will favor their own expendable launch vehicles wherever possible.

- Commercial - Currently commercial launches fall into two categories, communications satellites and R&D to investigate commercial opportunities. For communications satellites, the important parameters are price, schedule reliability, and launch vehicle reliability, with special consideration as to their effect on insurance costs. As competition increases, it can be expected that more launch decisions will be made on the basis of price.

  An evolving use of the Shuttle is exploration of the Shuttle capabilities for entreprenurial research and development activities to investigate the utility of the space environment for commercial opportunity. The current examples are the Johnson and Johnson/McDonnell-Douglas pharmaceutical experiments and the 3-M Corporation experiments. Some of the small self-contained payloads (Get-Away Specials) also fall in this category. The Administration encourages this type of activity by allowing NASA to enter into joint endeavor agreements at attractive pricing to stimulate experimentation and thus maximize the potential for development of private enterprise space activities.

If this experimentation results in the identification of large-scale commercial opportunities for high value products, then the whole perspective for Shuttle utilization, the need for heavy lift launch vehicles, and the role of man in space could change. However, since this activity is in its infancy, it is unlikely that it could affect Shuttle flight rate any sooner than about five years from now. This is a NASA/industry activity that the Group endorses wholeheartedly. It requires concentrated attention and effort and the Administration should be prepared to react swiftly with industry if positive results are to be attained.

In summary, the use of the Shuttle separates into two distinct categories, namely:

- As a launch vehicle to low Earth orbit for DOD satellites, commercial communications satellites, and scientific satellites. For this function, the Shuttle offers two advantages over the current family of expendable launch vehicles, namely its ability to launch heavier satellites and its ability to provide orbital checkout prior to deployment and use. This use of the Shuttle is governed by policy for U.S. Government payloads, and by price and schedule reliability for commercial and foreign payloads.
- As a facility to service and/or recover satellites and as an R&D facility to develop new uses of the space environment. In this application, the Shuttle is akin to large ground-based research facilities such as wind tunnels. This is the use of the Shuttle that is unique and is characterized by the presence of man, extended stay time on orbit, mission flexibility, and special capabilities (Remote Manipulator System, Extra-Vehicular Activity). In time, the space station will assume much of this capability, but for many years the Shuttle will be unique in this regard.

Of the two categories of use of the Shuttle, the first leads quite naturally to the idea of an operational system. The capability can be defined in performance specifications not unlike those of expendable launch vehicles. Mission operations and timelines can be largely standardized, crew and ground operations personnel training can be largely generic and, because the operation is reasonably standard, the schedule can be reliable and predictable. Differences from expendable launch vehicles still apply to this use, however. The presence of people on board requires a different approach to safety and increased attention to this aspect of safety of flight. The system represents a national capability for certain payloads and also for the R&D use of the Shuttle; this fact and the limited fleet size and size of investment dictate extra care and attention.

The second use of the Shuttle is less amenable to an operational focus, at least for a number of years. In this use, the customer will quite naturally and properly push to stretch the capabilities to the limit and to customize the mission to accomplish the customer's R&D objectives. Until and unless the Shuttle reaches a state of development beyond which it is impractical to expand its use further, this pressure will exist. This use of the Shuttle is still in its infancy. It is not so much dictated by the basic hardware design, but by exploring and understanding the ability of the crew and the vehicle to accomplish new and expanding tasks in space and thus exploit the full capability of the system as designed. This kind of pressure will inevitably lead to identification of marginal design changes in the Shuttle system to provide incremental performance improvements. This happens in all large systems and it should be carefully controlled but not discouraged. This use of the Shuttle, especially as it relates to joint endeavor agreements, DOD support, and scientific investigation, is quite analogous to the long-standing relationship between NASA and both the aeronautics industry and the scientific community in their respective endeavors.

C. Significance of the Space Shuttle

The use of space is still in its infancy. We only now have the capability to access space "routinely" and to begin to develop the true capabilities of man in space. Beyond its use as a launch, service, and recovery vehicle and as a platform for R&D in orbit, the Shuttle is a step in the evolution of manned space flight beginning with Project Mercury and now moving to the space station and later on to further options such as a lunar base or beyond.

The prospects for commercial opportunities in the space program are many and varied. Some of these are in space services such as commercial upper stages, commercial expendable launch vehicles, and commercial spacecraft buses as carriers for payloads. Others are in products and processes to be manufactured or developed in space. The Shuttle is key to the development of the latter activity and should be targeted toward this use of its unique capabilities, both in itself and as a transition to the space station which will have even greater utility in this regard.

Another important aspect of the Shuttle program is its use as an instrument of national and international policy. It is the prime asset available to promulgate international cooperation in space exploration. Through the Shuttle and Spacelab, NASA and ESA have formed a partnership in scientific investigation that is productive and important to both parties. The Shuttle also has importance in the international arena as a competitive force. It possesses capabilities unique in the world and thus forces serious consideration of its use internationally as well as leading other countries, notably the Soviet Union, to develop or consider developing similar capabilities. Shuttle flights attract worldwide attention and acclaim and provide a demonstration of U.S. technological and industrial strength that adds to U.S. prestige.

VI. Alternative Management Possibilities

A number of alternatives for managing the Shuttle both within and outside of NASA have been suggested. This section identifies the major alternatives considered and assesses them as to feasibility in the next five to ten years. Consideration covers operations, facilities, and all personnel performing the following:

- flight crew training, training and operation of mission crews, training and conduct of mission planning operations, maintenance of flight crew equipment, operation of flight crew training aircraft, system-wide sustaining engineering and configuration management, and Shuttle sustaining engineering and configuration management.
- engineering support of Shuttle flight operations and sustaining engineering and configuration management for the Solid Rocket Booster, Space Shuttle Main Engines, and External Tank.
- check out and launch of Space Shuttle flight hardware, recovery and safing of Orbiters, flight hardware modifications, sustaining engineering and configuration management of launch hardware and computerized ground processing systems, and assembly, checkout, recovery, and processing of Solid Rocket Boosters. These functions both at the Kennedy Space Center and Vandenberg Air Force Base would be included.
- budget formulation, overall system scheduling, total system management and direction, and single-point customer interface.

Although these lists are not complete, they do indicate the scope of activities that are now performed within NASA to support an operational Shuttle.

A. Shuttle as a Private Enterprise

The first alternative to be considered is operation of the Shuttle as a private enterprise. The scope of commercial operation would be characterized by:

- Ownership and operation of the Orbiter(s) and all associated flight hardware.
- Ownership or lease from the government of launch and landing facilities.
- Ownership or lease from the government of flight operations facilities at JSC or their duplication at some private facility.

- Ownership or lease from the government of simulator and training facilities or their duplication at some private facility.

- Employment of the flight crew (not necessarily to include mission and payload specialists).

- Responsibility to fund the replacement of flight hardware and ground facilities.

- Conduct of flight operations.

- Assumption of marketing and manifesting responsibility.

- Private provision of capital.

- Transfer of assets from the government at net book value determined through a formula that would have to be developed.

- Assumption of legal liability.

1. Implementation Issues

While a decision to transfer management of the Shuttle to a commercial firm would be consistent with the Administration's efforts to "privatize" appropriate government functions, certain conditions would have to be met to make such a transfer feasible:

- Government in conjunction with industry would have to define mutually acceptable terms. A similar situation may be privatization of the Landsat/Metsat system by the National Oceanic and Atmospheric Administration. NASA and industry would have to deal with not only many of the same issues, but also those peculiar to the Shuttle.

- The Administration and Congress would have to approve. The debate would likely raise such issues as: (1) whether the country was selling a major instrument of national prestige and policy; (2) whether the sale price and protection of government rights was adequate; and (3) whether NASA should retain an oversight role, and how that role might conflict with the operator's need for autonomy in operations.

- The operator would be required to demonstrate the capability to operate the Shuttle or to define a plan to develop the required capability over the period of transition from NASA.

2. Assessment

The private enterprise alternative, if viable, has in its favor access to debt and equity markets; that it would be financially self-sustaining rather than dependent on appropriations; and that it would be highly responsive to paying customers. However, the suggestion that the Shuttle should or could be transferred, sold, or leased to private enterprise for its operation, marketing, and future development is simply not a viable alternative for the foreseeable future--five to ten years. There are many reasons for this, but the overriding considerations are:

a. National Policy

The Shuttle is an instrument of national and international policy. The people of the world are interested in, and awed by, space and its exploits. It is, in fact, the new frontier and the U.S. government, among others, is using space as an instrument of policy. This is desirable and appropriate but would be difficult if the Space Shuttle were a commercial venture run by private enterprise with profit solely determining who could benefit by its use.

b. Government is the Major Customer

NASA and the DOD have a continuing need for a space capability that requires both facilities and vehicles. This need now constitutes the major part of the projected usage of the Shuttle. Until such time as a new commercial application comes along that can support facilities and vehicles of its own, there will not be a viable commercial operation. Proposals have been made to operate the Shuttle as a commercial operation, but they are more in the nature of marketing/financial arrangements and would rely on the government for dedication of the government's business, facilities, and perhaps vehicles, as well as its retention of responsibility. In the absence of a new commercial application, these are not viewed by the Group as attractive proposals and are certainly not economical for the government.

c. DOD Requirements

DOD requirements mandate government control. Access to space upon demand has become a very high priority for the DOD and, in their opinion, requires their control either directly or by a joint intragovernment arrangement such as they now have with NASA. Private enterprise operation of the Shuttle is incompatible with the DOD concept of its primary mission.

d. Potential Inhibition of the Commercial Use of Space

Premature privatization of the Shuttle may inhibit eventual commercialization of space. Research on new uses of space must be conducted, and this requires many experiments to be tried and the active participation of universities as well as of industry. Should one suddenly require the Shuttle to be profit making under a commercial operator, one could well inhibit just the kind of scientific research and experimentation that may well be the cornerstone of really new space technology. The magnitude of the investment in the system already made and the very substantial operating costs if transferred to a private concern would more than likely preclude much innovative and experimental use.

e. Liability Problems

The Shuttle is a state-of-the art system designed and built by or under the direction of the government, which has also developed the operational and safety procedures and has trained the astronauts. In this situation the liability for system failure must rest with the government, particularly in the case of a catastrophic failure. A private operator may be able to get first layer insurance coverage for his actions but the Group believes the government would have to retain the responsibility for major accidents. If the responsibility still largely rests with the government, it does not seem sensible to turn the system over to private enterprise, which may or may not operate in the government-approved manner.

B. Shuttle in a Quasi-Public Corporation

Management of the Shuttle could also be transferred to a non-NASA quasi-public corporation. The options are: (1) a wholly owned government corporation (e.g., Tennessee Valley Authority); (2) mixed ownership (e.g. Amtrak); or (3) a privately-owned but Government-sponsored corporation (e.g., Comsat Corp.). In each case, it is argued that a quasi-public organization would provide access to private capital to supplement appropriations, and that, free of government restraints, it could more effectively market and manage commercial opportunities.

1. Implementation Issues

Congress would have to establish the appropriate form of a quasi-public corporation. It would have to be consistent with the financial control provision of the Government Corporations Control Act as well as the numerous standard provisions on powers and immunities. Wholly owned corporations under Section 101 of that Act face more constraints than the other forms, but still have wide discretion in deciding how best to use available funds and contracting. Examples of corporations chartered with only limited Government controls and a high degree of flexibility are the U.S. Postal Service and the Corporation for Public Broadcasting. In the former case, the Congress deliberately tried to create a service with the attributes of a private corporation in the hope that business-type practices, subject only to minimal government controls, would increase efficiency of operations. In the latter case, the Corporation is heavily dependent upon government grants and audits but has the independence to avoid government interference with program content.

Congress would have to establish the corporation's funding provisions, i.e., revolving fund or private stock with or without "ownership" rights, depending on degree of government funding. In the case of Amtrak, the organization is a "for profit" corporation, but because Congress has dictated certain constraints, it may require many years before revenues equal or exceed expenses (if they ever do). It is assumed to be necessary for Congress to establish, through subsidies, an operating fund. At periodic intervals, the operations would be reviewed and the operating fund replenished. Congress thus retains the option to expand, modify, or contract services to satisfy national demands.

An agreement would have to be reached on the transfer of organizational elements and personnel and on the "selling price" of the "fleet." For example, in the case of Amtrak, the railroad shareholders received stock for the value of their passenger equipment. A suitable price would have to be agreed upon for the "sale" of government equipment and facilities.

The quasi-public corporation would have to negotiate agreements providing NASA and DOD with the requisite access and priority (not necessarily equal) and, for DOD, security. Pricing formulas for NASA and DOD would have to be mutually agreed to.

2. Assessment

While such a corporation might have some freedom to exercise marketing initiative, it is questionable whether, given the constraints such as its obligations to DOD, these efforts could be productive. On the contrary, it would appear that imposing this corporate structure on the Shuttle at this time would have serious negative impact.

Of greater significance is the fact that the Shuttle, unlike other quasi-public corporations such as Comsat, Amtrak, and the Tennessee Valley Authority, would not have sufficient non-government income potential to enable it to finance either acquisition or operations without reliance on government guarantees and appropriated funds.

C. Shuttle in DOD

The Group also considered the possibility of operating the Space Shuttle by the Department of Defense.

1. Implementation Issues

To effect a change of management to the DOD, all the activities listed for Shuttle operations would have to be transferred to DOD with an increase in DOD and/or contractor personnel of several thousand people and an increase in annual budget of some billions of dollars. This could be accomplished in several ways.

One way would be to transfer all STS-related people, facilities, budgets, and contracts to the DOD. This would result in a considerable loss of experienced people by NASA, an appreciable reduction in the NASA budget, and transfer of major facilities at NASA sites to the control of the DOD. An alternative approach could be to transfer a cadre of experienced NASA Shuttle personnel to the DOD in a phased transfer of responsibility over an extended period of time. This approach would require additional DOD authorized personnel and an extensive training program during the phaseover. The budgetary transfer would be phased over in the same period.

2. Assessment

Either of these approaches could be accomplished if directed. They would provide DOD additional control of Shuttle operations. However there are several undesirable features to placing STS operations in the DOD:

- Potential customers, both foreign and domestic, would be uneasy and some inhibited at the prospect of using a military controlled system.
- Some Shuttle users other than DOD itself would feel that schedules and priorities would be less secure.
- Given the national security mission of the DOD, the priority of the Shuttle for both budget and management attention would compete in a different way than it does in NASA. This competition might adversely affect the utilization of the Shuttle for commercial and civil agency purposes.
- The DOD does not appear to want this responsibility and might well resist that assignment.

The second approach, that of a cadre transfer and subsequent DOD build up, has two additional undesirable features:

- It would be time consuming and expensive, requiring dual staffing and budgeting for a period of from three to five years.

- The DOD is presently experiencing difficulties in adequately manning its own space programs. It would require additional manning and funding if given the responsibility for the entire program..

After a careful evaluation of this alternative, it is the opinion of the Group that placing Shuttle operations within the Department of Defense would not be a wise action. This transfer of responsibility to the DOD would not enhance the Shuttle in any way; rather it would add complexity and degrade the entire concept of peaceful exploration of space that has been so carefully built into the U.S. national space program from its very beginnings by Act of Congress.

D. Shuttle in Existing or New Government Department or Agency Other than NASA and DOD

Another alternative considered would be to transfer management to another civil agency. The President and the Congress would have to authorize the transfer and, if appropriate, charter the new organization with the needed flexibility to operate in the mixed government and commercial market for launch services. Transferring Shuttle management to an existing Cabinet-level department would provide Cabinet-level advocacy. If a new independent agency were created, it could be the home for other operational space systems first developed by NASA, as well. Further, as the commercial market for the Shuttle and attendant revenues grow, the departmental unit or independent agency could be transitioned to a quasi-public corporation or to commercial operation.

1. Implementation Issues

Congress would have to authorize the transfer and, if to a new agency or department, establish that organization.

NASA and the department or agency would have to negotiate the transfer of organizational elements and people and the "lease" or transfer of facilities. NASA might take the operational lead early in the transition process because of its knowledge of the system, but the department's or agency's authority in the negotiations would increase to assure effective integration into that organization's way of doing business. An arbiter other than the President would have to be identified for any disputes that arose.

Some space-experienced people would have to be added to the staff of the organization's head if he/she is to exercise any meaningful leadership and direction of the program.

There would have to be a redefinition of the decision and policy making processes in government to accommodate the new management approach to the Shuttle. This would take time to institutionalize.

Pricing formulas for NASA and DOD payloads would have to be mutually agreed to. NASA and DOD would each require guarantees of access and priority (not necessarily equal), and DOD would also require security guarantees. An interagency committee might have to be established to resolve differences and work problems between the agencies.

2. Assessment

As in the Shuttle in DOD option, this alternative could be implemented if directed. However, the Group concludes that this is not a viable option. In fact, there are serious problems that such a transfer would raise.

- Establishing a capability to operate the Shuttle in another government agency would result in a significant transition expense, and would lead to extensive duplication of personnel. Alternatively, transferring the NASA personnel and facilities to another agency would strain NASA's ability to perform its mission.
- The operation would be more complex in that it would involve new operational and organizational interfaces between the new agency and the DOD, NASA, and the commercial customers.

In light of the above, the Group does not consider placing the Shuttle operations in another government agency a wise course of action.

E. Shuttle in NASA

The foregoing sections serve to suggest that Shuttle operations should remain in NASA, rather than be transferred to other government organizations or to the private sector. The present NASA Shuttle operations organization is contained within the Headquarters office (Office of Space Flight - OSF) and field centers (JSC, KSC, MSFC) that manage both the development and operations of the system. Program authority flows from the OSF program elements to the program elements in the field through the center directors. Institutional authority flows from the Associate Administrator for Space Flight to the three center directors, who use the institutional resources thus provided to support the program, both development and operations.

1. Issues

The present system has successfully operated the Shuttle through a series of more and more complex missions with notable achievements being made on each mission. Thus the organization (NASA as a whole and OSF) has demonstrated the capability of operating the system while conducting R&D.

However, as the pace of operations quickens towards the planned 24 missions per year by about 1989 (reaching 12 per year in 1986), a number of concerns have been expressed which seem to indicate that Shuttle operations, while remaining under NASA management and control, must somehow be organizationally separated within the Agency. These concerns are:

- Diversion of NASA management attention to the operation of the Shuttle resulting in insufficient attention to the R&D responsibilities of the Agency.
- Diversion of funds from the R&D budget to the Shuttle operations budget and vice versa, thus working to the detriment of either or both.
- The ability of NASA as a primarily R&D agency to conduct Shuttle operations in an efficient, cost effective manner.
- The motivation for NASA as an R&D organization to stop "developing" the Shuttle and concentrate on using it.

2. Assessment

a. Management Attention

Five of the eight major NASA field installations have no significant involvement in Shuttle operations, although they will utilize the Shuttle for their R&D purposes. These are the Lewis, Langley, and Ames Research Centers, the Jet Propulsion Laboratory, and the Goddard Space Flight Center. The Dryden Flight Research Facility, which is now under Ames management, has been heavily involved in Shuttle landings at Edwards Air Force Base, but this should diminish as the plan is to routinely land at KSC with Edwards Air Force Base serving primarily as a weather alternate. Of the three OSF field centers involved (KSC, JSC, MSFC), KSC has the greatest percentage of its total resources dedicated to Shuttle operations. While KSC will have a substantial involvement in space station planning and facility development, steps taken already to streamline KSC Shuttle operations should assure adequate separation from a management standpoint. At MSFC, there is currently small involvement in Shuttle operations and that is expected to diminish over the next few years.

JSC is heavily involved in Shuttle operations and will also play a major role in space station development. Among the field centers, JSC is the location of greatest concern about the proper focus of management's attention, and careful attention to organization, manpower, and budget control procedures and priorities will be required. Action currently underway to consolidate contract activities at JSC similar to that already taken at KSC is a positive step towards streamlining that center's operations of Shuttle.

In Headquarters, only one program office, the Office of Space Flight, is heavily involved in Shuttle operations in addition to its R&D responsibilities. These R&D activities include continued Shuttle development activities as well as other Shuttle-related programs such as Spacelab and upper stages, and activities unrelated to Shuttle such as advanced programs. Contrary to popular belief, Shuttle development is winding down and Shuttle operations is now the predominate focus of this office.

b. Diversion of Funds Betweeen Programs

This concern must be addressed as it applies to the steps in the budget formulation and program implementation process. Within NASA the Shuttle is considered along with other NASA programmatic objectives, and from the process emerges a budget proposal that is submitted by NASA to the OMB. The OMB then goes through a similar process considering the constraints and objectives of all of Government, eventually resulting in the President's Budget to the Congress. The Congress, through its committee system, then engages in the third step in the process that culminates in an authorization and appropriation that, when signed by the President, establish the final program budget for that year.

The Group found that, after the appropriation process is complete, sufficient budget and cost controls and checks and balances exist that diversion of funds cannot occur without the full knowledge and consent of top management, the OMB, and the involved Congressional committees.

c. Efficient, Effective Conduct of Shuttle Operations

The Group could find no a priori reason that NASA could not conduct Shuttle operations in an efficient, cost-effective manner. It is important that the budgeting and accounting systems be used as tools to achieve efficiency and control costs as well as to provide a historical record of what happened. At this point in the program, a clear set of cost-reduction targets that can be tracked through the accounting system is a positive step that can be taken.

d. Motivation to Continue Development

The Group found little evidence that NASA is giving priority to continued development of the Shuttle rather than emphasizing its use. The principal ongoing development that the Group identified was that required to bring the system up to the current design specifications (e.g., bringing the Space Shuttle Main Engines up to the 109% power level and to service lifetime goals), to fix problems that have developed as the system has increased its activity level, and to meet new requirements (e.g., Centaur integration).

Another area of development the Group found of great importance and endorses is the ongoing development to expand the utility and attractiveness of the Shuttle system essentially as it exists. A primary example is the use of the Remote Manipulator System and Manned Maneuvering Unit to aid in the recovery and/or repair of damaged or adrift satellites. The Group endorses continued emphasis on developing systems that foster expanded use of the Shuttle to meet the important needs of customers.

VII. Conclusions

A. NASA's Mission

NASA's space mission as defined by the Space Act is to conduct space exploration for the benefit of all mankind. The Shuttle for the foreseeable future is the primary means for NASA to accomplish this mission.

B. Shuttle as a Valuable National Asset

The Shuttle system, and in particular the Shuttle Orbiter, has multiple capabilities and roles. Among these roles are:

- As a visible symbol of U.S. leadership in technology and in space accomplishment and as an instrument of national and international policy.
- As a critical element in the national security space program.
- As a launch vehicle for deploying satellites.
- As a platform for recovering satellites from orbit and repairing, refurbishing, or returning them to Earth.
- As a platform for conducting scientific, applications, and engineering experiments in and of space.
- As a platform for conducting experiments in space that may result in commercial products or processes.
- As an experimental vehicle to perform research and development to better define the flight environment and the limitations of the current system, and to provide basic data for the design of future systems.
- As a cornerstone in the total system required to fully explore space, with the next building block in the system being a space station.

C. The Shuttle Today and Tomorrow

Trends in the following factors affect the organizational requirements that may face any future operator:

- The Shuttle system will meet its capability requirements by the late 1980s.
- The launch and mission operations teams are in place and support the flight rate; they are working to a learning curve. Launch operations will become more routine, but the diversity of payload requirements may limit the extent of routine missions and cargo operations.

- The projected market demand of 24 flights per year is a reasonable one. There are uncertainties in the potential for growth in communications satellite business and new commercial markets, as well as in defense launches. Producibility of expendable Shuttle subsystems, sparing and logistics, and facilities now or soon to be available will support this launch rate. Market growth requiring as many as 30 flights per year will require a significant further investment.

- DOD requirements will continue to have the highest national priority and must be accommodated.

- NASA is placing high priority on fostering the commercial use of space and on attracting commercial customers to the Space Shuttle in the expectation that these activities will become profitable.

- NASA must take into consideration in the development of Shuttle price that it is important to foster the maximum utilization of the Shuttle to develop new products and processes.

D. Alternatives for Future Operation of the Shuttle

1. Private Operation of the Shuttle

The Group concludes that private operation of the Shuttle in the foreseeable future is not viable because:

- The Shuttle's use as an important instrument of national policy is inconsistent with private operation.

- Without a major new use, private operation cannot be both economically beneficial to the government and commercially viable.

- DOD requirements mandate government control.

- Private operation would inhibit the commercial development of new products and processes.

- A private operator could not relieve the government of its liability responsibilities.

2. Operation by a Quasi-Public Corporation

The Group does not consider operation of the Shuttle by a quasi-public corporation in the foreseeable future desirable because:

- The program would not have sufficient non-government income potential to enable it to finance either acquisition or operations without reliance on government guarantees and appropriated funds.

- The freedom to exercise marketing initiatives sometimes available to quasi-public corporations would be constrained by government dominance of the use of the Shuttle.

3. Operation by the DOD

The Group does not consider operation of the Shuttle by DOD to be desirable because:

- The U.S. policy regarding peaceful exploration and use of space would be perceived to changing.
- Operation of the Shuttle would have to compete with many high priority demands on DOD's resources.
- Potential customers, both foreign and domestic, would be uneasy and perhaps inhibited.
- DOD does not appear to want this responsibility; their mission does not include providing service for the range of current and prospective Shuttle users; and they may well resist such an assignment.

4. Operation by An Existing or New Government Civil Department or Agency

The Group does not consider operation of the Shuttle by another civil organization of the government desirable because:

- No other organization has the expertise to operate the Shuttle, and costs to develop that expertise are prohibitive.
- The Shuttle is needed for tasks and missions that NASA is best suited to support--space science, space applications, and space technology development.
- Establishing a capability to operate the Shuttle in another government agency would result in a significant transition expense and would lead to extensive duplication of personnel. Alternatively, transferring the NASA personnel and facilities to another agency would strain NASA's ability to perform its mission.
- The operation would be more complex in that it would involve new operational and organizational interfaces between the new agency and the DOD, NASA, and the commercial customers.

5. Operation by NASA

The Group concludes that NASA is the best agency to operate the Shuttle in the foreseeable future because:

- NASA's mission to conduct space exploration, including space science, space applications, space technology, and space station programs, depends upon the Shuttle.

- NASA has the required engineering, management, launch, and mission operations capability.

There are no inherent reasons why NASA cannot achieve optimum operation of Shuttle and effectively perform its overall R&D mission. As the Shuttle evolves and the flight rate increases, organizational realignments within NASA will become necessary to ensure that NASA's R&D and Shuttle operations do not detract from one another, but are mutually supportive. The goal of any such realignment should be to establish clear lines of operational responsibility, authority, and accountability. The Group believes the development of this realignment to be a line management function.

ACRONYMS

CSOC	Consolidated Space Operations Center (U.S. Air Force, Colorado Springs, CO)
DOD	Department of Defense
ELV	Expendable Launch Vehicle
ESA	European Space Agency
FY	Fiscal Year
JSC	Johnson Space Center (NASA, Houston, TX)
KSC	Kennedy Space Center (NASA, Titusville, FL)
MSFC	Marshall Space Flight Center (NASA, Huntsville, AL)
NASA	National Aeronautics and Space Administration
OMB	Office of Management and Budget
OSF	Office of Space Flight (NASA Headquarters)
R&D	Research and Development
SOPC	Shuttle Operational Planning Complex (in CSOC)
STS	Space Transportation System (includes Space Shuttle, facilities, and upper stages)
VAFB	Vandenberg Air Force Base (CA)

APPENDIX I

SHUTTLE OPERATIONS STRATEGIC PLANNING GROUP

A. Terms of Reference

Background

The question of NASA's long-term management role in Shuttle operation has been the subject of several studies in recent years. Most recently the NASA Advisory Council has concluded that several factors militate against shifting operations outside of NASA in the near future. One of the Council's recommendations was that:

> A new NASA organization be created at the appropriate time within NASA to focus on Shuttle operations and utilization, including marketing activities and sustaining engineering support. This organization, which should be headed by a Deputy Administrator, should have fenced manpower, finances, and facilities.

More recently, the House Committee on Science and Technology has asked the Agency for a "preliminary timetable for completion of activities to fence all Shuttle operating budgets, facilities and personnel along with the rationale for the timing of each milestone." The Office of Space Flight will address the Committee's specific request in a report to be provided to the Administrator.

In the longer term there is a need to address the permanent institutional and management options for the Space Transportation System. To this end the Administrator has appointed the Shuttle Operations Strategic Planning Group.

Objective

The objective of the planning activity is to provide and assess strategic options for managing and operating the Space Shuttle in the late 1980s and beyond which defines the transition steps and milestones, if any, and the institutional setting for Space Shuttle operations.

Scope

The Group is to address the institutional, financial, business, regulatory, legislative, national security, management, and organizational arrangements that would pertain to various options for future operation of the Space Transportation System.

Possible options to be considered include, but are not limited to:

1. The current arrangement with appropriate modifications (a civil effort under NASA and a national security effort under the Air Force).
2. A separate Space Shuttle operations organization
   - a. Within the government (other than Approach 1).
   - b. Within a quasi-government corporation.
   - c. Within the private sector.

The Group will examine the options, point out advantages, disadvantages, and any special Administration or Congressional actions required, and produce a skeleton plan for the implementation of each option for the consideration of the Administrator.

The results will be contained in a report to be provided to the Administrator.

B. Membership

Robert E. Smylie, Consultant (Chairman), Princeton, NJ
Charles W. Cook, Headquarters, USAF
Isaac T. Gillam, NASA Headquarters
Herbert E. Grier, Consultant, La Jolla, CA
Thomas J. Lee, NASA, Marshall Space Flight Center
Roger Lewis, Consultant, Washington, DC
William E. Lilly, Consultant, Arlington, VA
Glynn Lunney, NASA, Johnson Space Center
Leslie H. Meredith, NASA, Goddard Space Flight Center
Thomas W. Morgan, Consultant, Jemaz Springs, NM
Andrew J. Pickett, NASA, Kennedy Space Center
Gilbert Rye, National Security Council, Washington, DC (ex-officio)
Wilbur S. Smith, Consultant, Columbia, SC
Adolf K. Thiel, Consultant, Palos Verdes Estates, CA

Nathaniel B. Cohen, NASA Headquarters (staff)
Robert C. Fraser, NASA Headquarters (staff)
Carl R. Praktish, NASA Headquarters (staff)
Jane E. Scott, NASA Headquarters (staff)

C. Study Workplan

The Group's activities were a combination of (1) a series of fact-finding meetings at NASA Headquarters, involved NASA field centers, and relevant sites of USAF Shuttle activity, and (2) meetings to discuss the information acquired, consider the range of alternatives for managing and operating the Space Shuttle, develop findings and conclusions, and prepare a report for submission to the NASA Administrator. The meetings of the group and the matters considered at each are listed below:

1. September 10, 1984 - NASA Headquarters

Familiarization with subject and discussion with NASA management.

- STS Operations and Marketing - L. Michael Weeks
- Prior Studies of Management Alternatives - Isaac T. Gillam
- STS Marketing Plan and Market Estimate - Chester M. Lee
- Discussion with Administrator

2. September 19, 1984 - Marshall Space Flight Center

Fact-finding visit on Marshall STS activities.

- Overview - Joseph A. Bethay
- STS Systems, Organization, and Staffing - Robert E. Lindstrom, et al
- Productivity Enhancement, Simulation, and Test Activities - James E. Kingsbury, et al
- Payload Operations and Support - James E. Kingsbury, et al
- Upper Stages - Stanley R. Reinartz
- Spacelab - James A. Downey III
- Materials Processing as Shuttle Customer - William R. Marshall
- Tour of Facilities

3. September 20-21, 1984 - Kennedy Space Center

Fact-finding visit on KSC STS and cargo operations.

- Overview - Richard G. Smith
- STS Operations - Thomas E. Utsman
- Cargo Operations - Wylie E. Williams
- Design/Development Activities - John R. Lyon
- Institutional Operations - Robert G. Long
- Tour of Facilities

4. September 27-28, 1984 - Johnson Space Center

Fact-finding visit on JSC STS development, sustaining engineering, and mission operations.

- Overview - Gerald D. Griffin
- National Space Transportation System - Glynn S. Lunney
- Mission Planning and Payload Integration - Leonard S. Nicholson
- Mission Operations - Eugene F. Kranz
- Flight Crew Operations - George Abbey
- Mission Support - Jerry C. Bostick
- Orbiter - Arnold D. Aldrich
- Research and Engineering - Thomas L. Moser
- Tour of Facilities

5. October 25-26, 1984 - NASA Headquarters

Fact-finding visit to hear from private sector contractors and potential STS operators; potential use by Strategic Defense Initiative; status of NASA "fencing" study; discussion.

- Astrotech International - Don N. Stitt
- Orbital Sciences Corp. - David Thompson
- Ford Aerospace & Communications Corp. - Donn A. Starry
- Lockheed Space Operations Co. - A. R. Schroter, et al
- Rockwell International - George Jeffs
- Strategic Defense Initiative - Lt. Gen. James A. Abrahamson
- Fencing Study - Charles R. Gunn
- Delta Experience - Joseph B. Mahon

6. November 1-2, 1984 - Space Division (Los Angeles) and Vandenberg AFB

Fact-finding visit to learn of DOD activities; working session.

Space Division

- Introduction - Lt. Gen. Forrest McCartney
- STS Overview - B. Gen. Donald L. Cromer
- STS Activities - Lt. Col. Thomas Kumashiro
- STS Reimbursement - Col. Thomas J. Speed
- Security Procedures - Lt. Col. Paul Kruppenbacher

Vandenberg AFB

- Introduction - B. Gen. Donald W. Henderson
- STS Briefing - Col. Walter S. Yager
- Tour of Facilities

7. November 9, 1984 - Johnson Space Center

Preparation of detailed outline of report; discussion of points to be made in report. Meeting limited to small subgroup.

8. November 28, 1984 - NASA Headquarters

Discussion and revision of proposed report outline; determination of scope of assessment and character of findings and conclusions. Assignments given to members and staff to draft elements of report.

9. January 8-9, 1985 - NASA Headquarters

Discussion of first draft; revision of some sections and assignments to members and staff for rewrites.

10. January 23-25, 1985 - Johnson Space Center

Preparation of final draft of Group's report.

APPENDIX II

SUMMARY OF PRINCIPAL STATUTE AND POLICY

A. National Aeronautics and Space Act of 1958, as Amended

The National Aeronautics and Space Act of 1958, P.L. 85-568, was enacted July 29, 1958. In its provisions, it established national policy in aeronautics and space, established the National Aeronautics and Space Administration to conduct aeronautical and space activities, and carefully defined those activities. Relevant excerpts, including amendments through the end of calendar year 1984, are as follows:

1. Policy and Purpose

Section 102 of the Act contains the basic policy and purpose. The relevant paragraphs are:

> "(a) The Congress hereby declares that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind.
>
> "(b) The Congress declares that the general welfare and security of the United States require that adequate provision be made for aeronautical and space activities. The Congress further declares that such activities shall be the responsibility of, and shall be directed by, a civilian agency exercising control over aeronautical and space activities sponsored by the United States, except that activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States) shall be the responsibility of, and shall be directed by, the Department of Defense; and that determination as to which such agency has responsibility for and direction of any such activity shall be made by the President in conformity with section 201(e).
>
> "(c) The Congress declares that the general welfare of the United States requires that the National Aeronautics and Space Administration (as established by title II of this Act) seek and encourage, to the maximum extent possible, the fullest commercial use of space.
>
> "(d) The aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives:
>
> "(1) The expansion of human knowledge of phenomena in the atmosphere and space;

"(2) The improvement of the usefulness, performance, speed, safety, and efficiency of aeronautical and space vehicles;

"(3) The development and operation of vehicles capable of carrying instruments, equipment, supplies, and living organisms through space;

"(4) The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes;

"(5) The preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere;

"(6) The making available to agencies directly concerned with national defense of discoveries that have military value or significance, and the furnishing by such agencies, to the civilian agency established to direct and control nonmilitary aeronautical and space activities, of information as to discoveries which have value or significance to that agency;

"(7) Cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in peaceful application of the results thereof; and

"(8) The most effective utilization of the scientific and engineering resources of the United States, with close cocperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities, and equipment."

2. National Aeronautics and Space Administration

The National Aeronautical and Space Administration was established by Section 202. Section 203(a) authorizes the NASA to:

"(1) plan, direct, and conduct aeronautical and space activities:

"(2) arrange for participation by the scientific community in planning scientific measurements and observations to be made through use of aeronautical and space vehicles, and conduct or arrange for the conduct of such measurements and observations; and

"(3) provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

Additional provisions authorize the means by which NASA can discharge these functions.

3. Definitions

Section 103 defines the key terms appearing both in the NASA charter and the National policy.

> "Sec. 103. As used in this Act-
>
> "(1) the term 'aeronautical and space activities' means (A) research into, and the solution of, problems of flight within and outside the earth's atmosphere, (B) the development, construction, testing, and operation for research purposes of aeronautical and space vehicles, (C) the operation of a space transportation system including the Space Shuttle, upper stages, space platforms, and related equipment, and (D) such other activities as may be required for the exploration of space; and
>
> "(2) the term 'aeronautical and space vehicles' means aircraft, missiles, satellites, and other space vehicles, manned and unmanned, together with related equipment, devices, components, and parts."

B. Current National Space Policy

1. General

The National Space Policy announced by the President on July 4, 1982, reaffirms the national commitment to the exploration and use of space in support of our national well-being, and defines the following basic goals for U.S. space activities:

- Strengthen the security of the United States.
- Maintain United States space leadership.
- Obtain economic and scientific benefits through the exploitation of space.
- Expand U.S. private sector investment and involvement in civil space and space-related activities.
- Promote international cooperative activities in the national interest.
- Cooperate with other nations in maintaining the freedom of space for activities which enhance the security and welfare of mankind.

This policy reaffirms the U.S. commitment to the exploration and use of space by all nations for peaceful purposes and the benefit of mankind, but it also allows for space activities in pursuit of national security goals. It encourages domestic commercial exploitation of space capabilities, technologies, and systems for national economic benefit. It recognizes that there are two distinct but strongly interacting space programs, national security and civil, and reaffirms the necessity for close coordination, cooperation, and information exchange among these programs to avoid unnecessary duplication. Finally, the policy statement reaffirms that the Space Transportation System is the primary space launch system for both national security and civil government missions, and that its capabilities shall be developed to meet appropriate national needs and shall be available to authorized users, domestic and foreign, commercial and governmental.

2. Space Transportation System Policy

The Space Transportation System policy states that the Space Shuttle is to be a major factor in the future evolution of United States space programs, and that it will foster further cooperative roles between the national security and civil programs to insure efficient and effective use of national resources. The Space Transportation System (STS) is composed of the Space Shuttle, associated upper stages, and related facilities. The Directive establishes the following policies governing the development and operation of the Space Transportation System:

- The STS is a vital element of the United States space program, and is the primary space launch system for both United States national security and civil government missions. The STS will be afforded the degree of survivability and security protection required for a critical national space resource. The first priority of the STS program is to make the system fully operational and cost-effective in providing routine access to space.

- The United States is fully committed to maintaining world leadership in space transportation with a STS capacity sufficient to meet appropriate national needs. The STS program requires sustained commitments by each affected department or agency. The United States will continue to develop the STS through the National Aeronautics and Space Administration (NASA) in cooperation with the Department of Defense (DOD). Enhancement of STS operational capability, upper stages and methods of deploying and retrieving payloads should be pursued, as national requirements are defined.

- United States Government spacecraft should be designed to take advantage of the unique capabilities of the STS. The completion of transition to the Shuttle should occur as expeditiously as practical.

- NASA will assure the Shuttle's utility to the civil users. In coordination with NASA, the DOD will assure the Shuttle's utility to national defense and integrate national security missions into the Shuttle system. Launch priority will be provided for national security missions.

- Expendable launch vehicle operations shall be continued by the United States Government until the capabilities of the STS are sufficient to meet its needs and obligations. Unique national security considerations may dictate developing special purpose launch capabilities.

- For the near term, the STS will continue to be managed and operated in an institutional arrangement consistent with the current NASA/DOD Memoranda of Understanding. Responsibility will remain in NASA for operational control of the STS for civil missions and in the DOD for operational control of the STS for national security missions. Mission management is the responsibility of the mission agency. As the STS operations mature, the flexibility to transition to a different institutional structure will be maintained.

- Major changes to STS program capabilities will require Presidential approval.

On August 15, 1984, the President approved a National Space Strategy which reaffirmed the nation's commitments to the STS program and charged NASA and DOD with joint preparation of a report to define "a fully operational and cost-effective STS" and to specify the steps leading to that status. NASA was further charged with developing a time-phased plan for implementing full cost recovery for commercial and foreign STS flight operations occurring after October 1, 1988, by which date the STS would be "fully operational." The Office of Management and Budget (OMB) and other involved agencies were charged with an assessment of international competitiveness of both U.S. commercial ELVs and the STS.

That strategy was augmented on February 25, 1985, by a National Security Launch Strategy. The key elements include agreement that the Air Force will procure 10 expendable launch vehicles for use at a rate of about 2 per year from 1988 through 1992, commitment by the DOD to at least one-third of the STS flights during the next 10 years at a price (to be determined) that provides a positive incentive, and joint DOD/NASA study of a second-generation space transportation system.

3. Expendable Launch Vehicle Policy

In May 1983, the Administration announced issuance of a President's Directive on Commercialization of Expendable Launch Vehicles consistent with the National Space Policy and designed to encourage U.S. private sector investment and involvement in civil space activities. This policy was later implemented by an Executive Order (February 24, 1984) designating the Department of Transportation as the lead agency in commercialization of U.S. expendable launch vehicles.

The basic goals of U.S. space launch policy stated in the Directive are to:

> "(a) ensure a flexible and robust U.S. launch posture to maintain space transportation leadership; (b) optimize the management and operation of the STS program to achieve ~~rout~~ine, cost-effective access to space; (c) exploit the unique attributes of the STS to enhance the capabilities of the U.S. space program; and (d) encourage the U.S. private sector development of commercial launch operations".

The policy includes U.S. Government endorsement of the commercialization of expendable launch vehicles, provisions for appropriate U.S. Government support of such activities, constraints dictated by legal, safety, and security considerations, and guidelines for pricing of support without subsidization.

The policy also states that the U.S. Government will continue to make the Space Shuttle available for all authorized users--domestic and foreign, commercial and governmental--subject to U.S. Government needs and priorities. Through FY 1988, the price for STS flights will be maintained in accordance with the currently established NASA pricing policies in order to provide market stability and assure fair competition. Beyond this period, it is the U.S. Government's intent to establish a full cost recovery policy for commercial and foreign STS flight operations.

4. Policy on Commercial Use of Space

On July 20, 1984, the President issued his National Policy on the Commercial Use of Space. The policy includes four sets of initiatives: (1) economic initiatives, centering on tax laws and regulations which discriminate against commercial space ventures; (2) legal and regulatory initiatives, to update existing laws and regulations to accommodate commercial use of space; (3) research and development initiatives, to expand basic research and development which may have implications for investments in commercial space products and services; and (4) policy initiatives, to assure an environment conducive to commercial endeavors over the long periods of time required. As part of the last initiative, a Working Group on Commercial Use of Space was established under the Cabinet Council on Commerce and Trade. The Group is chaired by a representative of the Department of Commerce, a representative of NASA is vice chairman, and representatives of other interested departments and agencies comprise the membership.

APPENDIX III

SUMMARY OF PRIOR STUDIES

In the past 10 years, a number of studies of alternatives for the future operation of the Space Station have been conducted (References 1-7). They have, almost without exception, concluded that operations responsibility should remain in NASA. Some have concluded further that some degree of separation between Shuttle operations and NASA R&D would be desirable. These conclusions are based upon assessments of the advantages and disadvantages identified with each of the organizational alternatives of the studies. The tabulation of pros and cons that follow is derived from those of the NASA "Analysis of Policy Issues" (Reference 6); the items are typical of the advantages and disadvantages identified by all the listed studies. The organizational alternatives presented here are those that are addressed in the present report.

A. Organizational Alternatives

1. Commercial Corporation*

Pro

- Access to debt and equity market
- Financially self-sustaining and out of public appropriated funds
- Allows pricing for profit
- Not subject to personnel and procurement regulations
- Highly responsive to non-DOD community
- Permits financial incentives in marketing
- Consistent with Administration's efforts to emphasize private sector rather than government involvement

Con

- Cannot be implemented in near term without significant harm to NASA R&D base
- Financial risk/bankruptcy
- Government loses control of civil access to space
- May increase user's transportation costs

---

*DOD maintains own operations.

2. Government Corporation

Pro

- o Access to both appropriations and capital markets
- o Allows pricing for profit
- o May not be subject to personnel and procurement regulations
- o Flexible charter
- o Responsive to non-DOD community
- o Permits financial incentives in marketing

Con

- o Cannot be implemented in near term without significant harm to NASA R&D base
- o May increase user transportation costs
- o May conflict with DOD needs to control national defense system

3. DOD Operation

Pro

- o Symbolic of military use of space
- o Assures national defense interests
- o Unity of control
- o Possible benefit to NASA R&D budget
- o Promotes DOD use of Shuttle
- o Allows long-term focus of NASA's resources on R&D

Con

- o Cannot be implemented in near term without significant harm to NASA R&D base
- o Inhibits open, peaceful use of space
- o Probable lack of responsiveness to civil space needs

- o Competition with other high priority national defense needs
- o Politically unfeasible

4. Existing or New Department or Agency Other than NASA or DOD

Pro

- o Allows NASA to focus on R&D
- o Removes Space Transportation System from NASA R&D funding
- o Possible Cabinet level advocacy
- o Symbolic of national commitment to space transportation system (new department or agency)
- o Emphasis on customer services and expanded markets (new department or agency)

Con

- o Cannot be implemented in near term without significant harm to NASA R&D base
- o May conflict with DOD need to control national defense system
- o Competes with existing agency programs (existing organization)
- o No compelling motivation to make change
- o Politically inconsistent with current Administration's efforts to reduce federal bureaucracy (new department or agency)

5. NASA/DOD Partnership (Current Evolutionary Plan)

Pro

- o Organization, management, and budget linkages in place
- o Record of success
- o Unity of control, responsibility, and accountability
- o Could preserve NASA Space Shuttle R&D experience base and support of new starts
- o Improved responsiveness to national defense system

Con

- o May conflict with DOD need to control national defense system
- o NASA perceived to be non-responsive to user's needs
- o Security requirements inconsistent with NASA's open mode of operation
- o May detract from NASA R&D focus

B. References

1. Aerospace Corporation, Integrated STS Operations Planning (Study 2.5) Final Report, Prepared for NASA under Contract No. NASW-2884, 16 July 1976.
2. National Academy of Public Administration, U.S. Space Transportation in the 1980's: Organizational Alternatives, Prepared for NASA under Contract No. NASW-2989, June 1977.
3. Gillam, Isaac T. IV, NASA, Space Transportation System Organizational Alternatives, February 1982.
4. Office of Technology Assessment, Civilian Space Policy and Applications, June 1982.
5. Huberman, Benjamin, Retaining STS Operations in NASA Over the Longer Term, Prepared for NASA under Contract No. NASW-3596, August 1982.
6. NASA, National Space Transportation System: Analysis of Policy Issues, August 1982.
7. NASA Advisory Council, Study of the Mission of NASA, October 12, 1983.

APPENDIX IV

MARKET PROJECTION AND SHUTTLE PRICING

In 1977, NASA published a Shuttle reimbursement policy for commercial and foreign customers of the Shuttle. This policy was based on the principle that the Government should eventually recover its total operating costs for Shuttle. Pricing was based on a fixed, flat rate price for the first three years of the program. This price reflected the then current estimate of the twelve year average total operating costs for the system. The fixed-price period, Phase I, which became Fiscal Years 1983, 1984, and 1985, was to be followed with incremental adjustments thereafter. In 1982, NASA announced both a new price and a new pricing policy for Shuttle. For Phase II of Shuttle operations, Fiscal Years 1986, 1987, and 1988, NASA would charge a price based on recovering the out-of-pocket cost to the government of Shuttle operations. This price includes the average total operating cost for the consumable items of the Shuttle and average additive cost for launch operations support and flight operations support.

In response to national policy that, beginning in FY 1989, Shuttle pricing be established to recover the full cost of operating the system, NASA has developed a cost model for that period. The average estimated costs of Space Shuttle flights during the time period FY 1989 through 1991 is $83.3 million (FY 1982 dollars). This average is based on a sustained flight rate of twenty-four flights per year, expected to be first achieved in FY 1989. The costs include all direct and indirect costs as well as allocations of institutional support costs associated with Space Shuttle operations. The projected average operating costs in millions of FY 1982 dollars are:

	FY 1989	FY 1990	FY 1991	Average
Cost per Flight	83.9	83.6	82.5	83.3

The costs for FY 1989 through FY 1991 are based on an analysis of actual cost performance to date and projections of continuing trend improvement through FY 1994. The actual performance data base varies by project reflecting, at a minimum, completion of 12 successful flights. Some projects have larger data bases; for example, the External Tank estimates reflect completion of 20 flight units and partial completion of 15 more which are now in process.

This data base is conservative since many project areas were perturbed by continuing development of the system and numerous technical and schedule changes in the early stages of the program life cycle. A similar analysis was performed during FY 1982 to support establishment of the FY 1986 through FY 1988 pricing policy. Subsequent actual costs, as well as the proposed operating budgets for FY 1985 and FY 1986, have tracked closely and somewhat below the estimates included in the previous study. The current estimates were developed in a similar manner to the previous study and augmented by subsequent actual experience. The present cost model includes the cost to supply or refurbish, as necessary, all flight hardware (External Tank, Solid Rocket Boosters, Orbiter, Crew Equipment, and Main Engines), to provide flight and launch operations, and allocations of network support and the institutional support funded by the appropriation for research and program management. It does not include recoupment of sunk costs for research and development of the Space Shuttle, nor does it include costs for amortization of the Shuttle Orbiters, which were developed and procured as a national resource required for government operations. It does, however, include the cost of refurbishment and spares for the Orbiter and the costs of operations and maintenance of facilities. It also includes a higher cost for comparable launch support services than those charged in accord with present policy for commercial ELVs.

The mission model used in the present cost model is based on 24 flights per year in the 1989-1991 period. This flight rate is based on the best data available for national security requirements, NASA requirements, other government requirements, and commercial and foreign flights. By category of user, the model is:

NATIONAL STS TRAFFIC MODEL

CUSTOMER	1989	1990	1991
NASA	6.8	9.3	8.3
COMMERCIAL AND FOREIGN	2.0	4.2	4.2
DOD	13.8	9.2	10.2
REFLIGHT OPPORTUNITY	1.4	1.3	1.3
STS MODEL	24	24	24

APPENDIX 14

NASA
National Aeronautics and
Space Administration

Washington, D.C.
20546

C:JM:jmb

Honorable Don Fuqua
Chairman
Committee on Science and
Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

In the House Authorization Report 98-65, the Committee requested NASA submit to Congress an annual report on the NASA Materials Processing in Space Program.

I have enclosed the report for 1984 in compliance with the Committee's request. Please call me if you have any questions about the report.

Jack Murphy
John F. Murphy
Assistant Administrator
for Legislative Affairs

Enclosure

RECEIVED
JUL - 1 1985
COMMITTEE ON SCIENCE
AND TECHNOLOGY

MICROGRAVITY SCIENCE AND APPLICATIONS ANNUAL REPORT

I. INTRODUCTION

This report contains a summary of the National Aeronautics and Space Administration (NASA) activities in Microgravity Science and applications. It provides a restatement of our goals and objectives and an overview of the flight and ground-based research programs, highlighting the accomplishments of the past year and plans for the next year.

The interest in the program, on the part of both the scientific and industrial research communities, has grown markedly in the last year. The number of research proposals received has doubled over the last year, and the quality of the majority of proposals is also continuing to increase.

Two organizations were selected to establish Centers for Organic Separation and Pharmaceuticals. The Centers will be located at the University of Arizona, Tucson, and the University City Science Center, Philadelphia, PA.

The inventory of experiment apparatus has grown substantially, with eight distinct pieces completed in 1984. Progress is also being made on several other pieces of equipment.

Significant progress has been made in the establishment of sound management practices within the program. The budget has been realigned in order to provide separation between the ground and flight research budgets. Flight program budgeting is now done on a multi-year basis to ensure that the entire lifetime of an individual program is adequately planned. A series of reviews covering the technical, scientific, and programmatic aspects of each flight project has been instituted and standardized across the Microgravity Science and Applications Program.

II. GOALS AND OBJECTIVES

The goals of the NASA Microgravity Science and Applications Program are:

1. To investigate the behavior of materials and fluids, and the effects on processes carried out in the microgravity environment;
2. To provide a better understanding of the effects and limitations imposed by gravity in processes carried out on earth;
3. To evolve processes that exploit the unique characteristics of the microgravity environment of space to accomplish results that cannot be obtained in unit gravity; and,
4. To explore and determine potential applications for the commercial use of space.

Near-term efforts to achieve these goals include expanding the research base, fostering an increase in the awareness of the microgravity program in both industry and academia, broadening commercial and applied activities, and the establishment of a long range program plan. Full advantage will be taken of the Space Transportation System (STS) flight opportunities made available to the microgravity program. Considerable emphasis will be placed on research and equipment design leading to optimized usage of the Space Station.

III. PROGRAM OVERVIEW

The Microgravity Science and Applications Program concentrates on the physical sciences, but does not include the study of the effects of gravity on living organisms (research in this area is conducted under the auspices of the NASA Life Sciences Program).

The Microgravity Program is made up of six distinct disciplines:

- Electronic Materials
- Biotechnology
- Metals and Alloys
- Glasses and Ceramics
- Combustion Science
- Fluid Dynamics and Transport Phenomena

Supported research efforts are conducted at approximately 60 universities, 10 industrial organizations, 3 non-profit organizations, the National Bureau of Standards, 4 NASA Field Centers, and the Jet Propulsion Laboratory.

There are two elements to the program: flight research and ground-based research. Flight research includes the apparatus development, principle investigator support, and data analysis activity directly related to flight aboard the STS. Three different flight modes are available: the middeck area, the cargo bay on specially designed support structures, and the Spacelab pressurized module. The flight program makes use of all of these modes.

The ground-based research program consists of laboratory research at Principal Investigators (PI) home institutions and use of unique NASA ground-based facilities, including drop tubes, drop towers and aircraft. Use of these ground-based facilities establishes the necessary criteria prior to commitment to space flight. In addition, a Microgravity Materials Science Laboratory (MMSL) has been established at the Lewis Research Center in Cleveland, Ohio.

IV. SUMMARY OF 1984 ACTIVITY

FLIGHT RESEARCH PROGRAM

During 1984, several pieces of apparatus were completed and either flown or are now ready for integration and flight on the STS. These are as follows:

Acoustic Containerless Experiment System (ACES)
Isolelectric Focusing System (IEF)
Automated Directional Solidification Furnace (ADSF)
General Purpose Furnace-3 (Gradient) (GPRF-3)
General Purpose Furnace-4 (Gradient) (GPRF-4)
Electromagnetic Levitator (EML)
Fluid Experiment System (FES)
Vapor Crystal Growth System (VCGS)

Conceptual Design Reviews were held on two Physics and Chemistry Experiments (PACE) and both were tentatively approved for inclusion in the flight program. The first experiment is Solid Surface Combustion, the PI is Dr. Robert Altenkirch of the University of Kentucky. The second is the Specific Heat of Helium through the Lambda Point, the PI is Dr. William Fairbank of Stanford University, assisted by Dr. John Lipa.

Tentative approval for flight development was also given to the Advanced Automatic Directional Solidification Furnace (AADSF), which will be the first piece of second generation microgravity hardware built for flight on the STS. The AADSF is designed to provide a broad range of materials processing conditions, and will be used for the processing and growth of crystalline electronic materials, for example, Mercury Cadmium Telluride (HgCdTe).

Professor Harry Wiedemeier of the Rensselaer Polytechnic Institute completed the analysis of his vapor crystal growth experiment flown on STS-7 in June 1983. Germanium Selenium (GeSe) crystals were grown by physical vapor transport in closed ampoules with a Xenon (Xe) buffer gas at 4 and 8 atmospheres, using the General Purpose Rocket Furnace (Gradient) (GPRF-2). The main objective of the experiment was to resolve the anomalous transport rates observed in GeSe growth experiments done on the

Skylab and Apollo-Soyuz programs. The transport rates observed in Dr. Wiedemeier's experiment were within 20% of predicted rates and a factor of two lower than ground control tests, tending to confirm his theory that the prior anomalous rates were due to thermochemical effects of the homogeneous gas phase reactions. A two-dimensional transport model is being developed by Dr. Tim Miller of the Marshall Space Flight Center to explore the details of these results. The model will also be used to assist in the data analysis of the vapor crystal growth experiment flown on the STS by the 3M corporation.

Dr. Wiedemeier's experiment not only achieved its original objective, but also produced a surprising and unexpected result. The ground control experiments produced a thin crust of polycrystalline material on the wall of the growth region with individual crystallites no larger than 1mm. This was considered acceptable since the objective of this particular experiment was to measure transport rates, not necessarily to grow good crystals. The flight samples, however, produced loose web-like structures of large, thin crystals that grew in the interior of the growth ampoule instead of on the wall, suggesting that the crystals nucleated homogenously in the gas phase. Some of these crystals were as large as 4 X 10mm and were 10-100 microns thick. The ground control crystallites show numerous and irregular growth terraces with a swirl-like pattern, suggesting significant convective flow. The earth-grown crystals also show a high density of surface pits, the origin of which has not been identified. The space-grown samples, in contrast, are extremely smooth with more regular and widely spaced growth terraces and showing no evidence of surface pitting. These samples were grown under identical conditions except for the gravity field. It is clear that the more uniform growth conditions in the absence of gravity-driven convection have a profound effect on the surface morphology.

In the area of biotechnology, more detailed analysis of the sample constituents and properties in Continous Flow Electrophoresis (CFE) was conducted in 1984. Flight experiments on STS-6 and 7 showed the importance of different electrical properties; the electrical conductivity of the sample and the buffer solution must be carefully matched to avoid electrical field distortions, and, thus, fully utilize the high sample concentration possible in low gravity. It has been shown that dramatic increases in throughput can be realized in CFE performed in low gravity by increasing the flow channel width and the concentration of the sample stream. This is highly significant for commercial applications of CFE, since this is a major advantage of low gravity operations.

The NASA sample runs conducted under the Joint Endeavor Agreement (JEA) with McDonnell Douglas, gave us some insight on the effect of conductivity mismatch between the sample stream and the buffer. In addition, live kidney and pituitary cells were separated on STS-8. One of the objectives was to isolate the subfractions of kidney cells that produce the largest amounts of urokinase (plasminogen activator), and also to isolate the subfractions of rat pituitary cells that secrete the growth hormone, prolactin, and other hormones. Kidney cells were separated into more than 32 fractions in each of two electrophoretic runs. Multiple assay methods confirmed that all cultured kidney cell fractions produced some urokinase, and five to six fractions produced triple or more the urokinase than the other fractions. Several fractions also produced tissue-plasminogen activator.

The pituitary cells were separated into 48 fractions. The patterns of hormone distribution indicate that the inflight control pituitary cells did not secrete nearly as much growth hormone into the maintenance medium as did the ground controls.

The Monodisperse Latex Reactor(MLR) has flown five times on the Space Shuttle (STS-3, 4, 6, 7, and 11) and has produced the first commercial materials ever manufactured in space to be marketed on earth. The National Bureau of Standards will begin sale of the 10 micrometer latex beads, manufactured during STS-6, as the United States National 10 micrometer Standard Reference Material.

NBS has also officially requested that NASA make available 30 grams of 30 micrometer latex and 80 grams of 100 micrometer latex beads to also be used for Standard Reference Materials. Three additional flights of the MLR are planned. The Principle Investigator on the MLR is Dr. John Vanderhoff of Lehigh University.

These large-sized monodisperse spheres have several possible scientific applications, including such things as drug carriers and tracers in the body, animal and human blood flow studies, membrane and pore sizing in the body, and medical diagnostic tests. Other applications include use of calibration standards for optical and electron microscopes, Coulter counters, light scattering devices, and other types of laboratory equipment.

Programmatically, $4M was reallocated within the OSSA program into the Microgravity Science and Applications flight program for FY 1985. This additional funding will allow for orderly completion of apparatus already in process.

A series of reviews has been established as standard for flight hardware development in the Microgravity Science and Applications program. These reviews ensure the consideration of all key aspects of each project while development is underway. Of foremost consideration is the continuing involvement of a science panel to validate that the hardware development is consistent with the approved science requirements. In addition, programmatic status is reviewed in detail to assure adequate resources to effectively complete the project.

GROUND-BASED RESEARCH PROGRAM

In 1984, the number of research proposals doubled over the prior year, indicating the increase in awareness of and interest in the program (Figure 1). The number of papers by NASA Microgravity Science and Applications sponsored investigators in refereed journals also continues to increase (Figure 2).

The ground-based program is made up of approximately 100 individual research tasks in the six program discipline areas. The majority of tasks are intended to lead directly to an eventual flight project; some are specifically intended to provide the mathematical and theoretical models against which microgravity experiment results are analyzed and evaluated.

The following highlights represent a cross section of the activity in the ground based program.

- Electronic Materials

Dr. Klaus Bachman of North Carolina State University is conducting experiments in the II-VI materials, a family of compound semiconductors which can be lattice matched for the growth of epitaxial mercury cadmium telluride (HgCdTe). In order to develop more information on the growth of these materials, Dr. Bachman has grown crystals of cadmium telluride (CdTe), zinc cadmium telluride (ZnCdTe), manganese cadmium telluride (MnCdTe), and cadmium selenium telluride (CdSeTe) by the Bridgman technique. The CdTe crystals exhibit photoluminescence at room temperature, which implies that the crystal quality is very good. Photoluminescence measurements on the ZnCdTe show the deep level as being compositionally dependent, but a constant distance from the band edge, i.e. as the zinc content is increased, the band gap increases and the energy level of the deep level increases at the same rate. The deep level also exists in the CdSeTe. Further studies of these materials are planned to determine the cause of the deep level and to explain its unusual dependency on the various materials parameters.

Ground-based tests for the effects of convection on crystal homogeneity and morphology are continuing. A technique for electrochemically etching lead tin telluride has been developed. Preliminary results indicate significant differences in the morphology of the crystals grown by directional solidification when a free surface is present in a vertical downward growth (gravity in a direction opposite the growth direction).

o Biotechnology

Dr. D.E. Brooks of the University of Oregon is conducting a research program in cell partitioning in two polymer aqueous phases. Cell partitioning techniques are being developed as an analytical and preparative procedure for biomedical research and biotechnology. In 1984, polymer phase systems were flown on the KC-135 for comparison to Shuttle experiments. Effort is continuing in characterization of electric field driven phase separation in unit gravity for comparison against microgravity tests.

Ground-based research is also being conducted in electrophoresis technology, in order to understand the hydrodynamic and electrokinetic processes involved. This activity supports the McDonnell Douglas Continuous Flow Electrophoresis System flights as well as NASA-supported research.

o Metals and Alloys

Dr. Ared Cezairliyan of the National Bureau of Standards initiated an investigation using the KC-135 aircraft to determine if pulse calorimetry techniques of measuring the thermophysical properties of metals can benefit from microgravity. Earth-based techniques restrict the measurements to solids because the liquid zone falls when the metal becomes molten. Initial tests showed that a liquid zone (using mobium) can be maintained up to 50 degrees of superheat.

Dr. Mary Helen Johnston of the Marshall Space Flight Center conducted an investigation to solidify samples of MAR-M246 in low gravity and compare these samples to ground-processed specimens. MAR-M246 is a nickel-based superalloy with carbon and boron fibers used in high temperature applications. The low-gravity samples had a different secondary dendrite spacing, a decrease in carbide volume fraction, and a carbide shape change. These results could enhance the high-temperature properties. Restrictions on low-gravity time in the KC-135 have led Dr. Johnston to propose a Shuttle-based experiment in this area.

A series of F104 flights were conducted to "quench" samples of cast iron in low gravity. The tests were in support of the Deere and Company Technical Exchange Agreement. The purpose of the tests was to see if grey iron could be cast in the amount of low-gravity time available on the aircraft. The experiments were successful and the specimens are currently being analyzed by NASA and Deere and Company.

- Glasses and Ceramics

The ability to prepare inorganic oxide glasses can be limited by the tendency of the melt to heterogenously nucleate and crystallize from the container wall. Thus, under space conditions that allow containerless glass formation, it should be possible to prepare glasses containing different and greater modifying ion content than can be accomplished on earth. Containerless processing could, therefore, lead to production of new glass compositions of high technological value. Researchers at the Jet Propulsion Laboratory are currently involved in the preliminary research leading to eventual Shuttle experimentation.

- Combustion

The flammability limits research done by Professor Roger Strehlow of the University of Illinois reached a significant milestone during 1984 with the first flights of combustion experiments aboard a NASA Learjet. A series of flights, during which six separate experiments were performed, provided the first low-gravity flame tube experiments in which flames could proceed to completion. The unique 3-axis acceleration measurements recorded in synchronization with the flame experiments have provided data which is now being used to examine correlations between gravity perturbations and the stability and speed of flame propagation.

With the advent of the major planning efforts for the Space Station, the Microgravity Science and Applications program was asked to participate in an assessment of the state-of-the-art in Spacecraft Fire Safety. The current level of knowledge will be evaluated to determine the direction of future research and technology development efforts.

- Fluid Dynamics and Transport Phenomena

The Fluid Dynamics and Transport Phenomena area is a multifaceted, multidiscipline program. A significant amount of research in this area is conducted under the auspices of the Physics and Chemistry Experiments program described below. In addition, this discipline focuses on the investigation of fluid processes specifically associated with materials science, and, as such, might be referred to as an applied fluid physics program. Two areas of concentration are the oscillatory motions of liquid drops and the geophysical fluid flow experiments and complementary theoretical studies.

In the areas of semiconductor crystal growth and metals and alloys, the work sponsored under this discipline has been responsible for major advancements in understanding such phenomena as surface tension driven convection, thermosolutal flows, transient phenomena in fluid transport, electromagnetic effects on fluid flows, and Marangoni flows. These results have been widely utilized by the semiconductor industry for advancements in materials technology and processing.

- Physics and Chemistry Experiments(PACE)

The basic purpose of the PACE program is to facilitate the utilization of space as a laboratory for basic research in the areas of physics and chemistry. The ground-based PACE program provides for research and technology development with an eye towards eventual space flight. Basic research is conducted, as well as conceptual design of flight apparatus. A listing of the current PACE experiments is shown in Table 1.

- Centers of Excellence

In addition to the specific research tasks, this element of the program also includes funding to four Centers of Excellence in areas related to the microgravity disciplines. These Centers include: the Materials Processing Center at the Massachusetts Institute of Technology; the Institute for Theoretical Physics at the University of California, Santa Barbara; the Bioprocessing Research Center, University City Science Center, Philadelphia; and the Bioprocessing Center, University of Arizona, Tucson. All of these Centers receive a core grant, funding which is completely at the discretion of the Center. This core grant is used to provide for the basic institutional needs of the Center, facilities, equipment, personnel, supplies, etc., as well as to fund research solicited and selected by the Center.

The two Centers in Bioprocessing Research were competitively selected in 1984 by a blue-ribbon panel of experts in bioprocessing and related fields. The Centers were established consistent with the FY 1984 Congressional Authorization.

The Center located at the University City Science Center in Philadelphia, Pennsylvania, is headed by Dr. Paul Todd of Penn State University. A consortia of 12 universities in Pennsylvania are participating under Dr. Todd's direction.

The Center located at the University of Arizona is headed by Dr. Milan Bier. The purpose of both Centers is to conduct research in biological processing, including separation techniques, in microgravity. The Centers will have participating researchers from both the industrial and academic communities, and are expected to obtain significant additional funding from industrial sources, as well as from state and local governments, in addition to the seed funding from NASA.

o Microgravity Materials Science Lab

Another element of the ground-based research program is the Microgravity Materials Science Lab (MMSL) at the Lewis Research Center in Cleveland, Ohio. The purpose of the MMSL is to provide access to industry, academic, and government researchers who wish to conduct materials science and technology research on experiment apparatus similar or identical to that being flown on the STS. The MMSL will be fully equipped with materials research and analysis facilities and will be supported by the extensive LeRC materials characterization and computational capabilities. The facility will be used to fully explore the baseline earth gravity behavior of materials or processing phenomena in support of reduced gravity experimentation on the STS and/or Space Station.

o Ground Facilities

Simulation of microgravity conditions is an important element in determining the need for space flight experimentation prior to the commitment of flight development funding. The NASA Microgravity program utilizes drop tubes, drop towers, and aircraft to provide this verification.

Drop tubes are capable of accommodating small uncontained material samples. Four drop tubes, each having unique capabilities, are currently operational and available for research studies. These include: 1.) a 100 meter drop tube at MSFC, capable of providing up to 4.6 seconds of microgravity; 2.) a 30 meter drop tube also at MSFC, which provides 2.6 seconds of free-fall time; 3.) a 13.7 meter force-free drop tube at the JPL, which provides up to 1.7 seconds of microgravity; and, 4.) a 13.2 meter cryogenic drop tube at JPL which provides a vertical sample free-fall time of 1.7 seconds in vacuum.

Drop towers have the capability of accommodating large experimental packages. Three drop towers of varying capability are currently available. These are: 1.)a 145 meter drop tower with a vacuum drop chamber, capable of 5 to 10 seconds of microgravity time, located at the Lewis Research Center; 2.) a 30 meter drop tower, also at LeRC, capable of 2.2 seconds of microgravity; and, 3.) a 100 meter drop tower, located at MSFC, capable of 4.275 seconds of microgravity.

In addition, three aircraft capable of 15 to 60 seconds of free-fall time by flying parabolic trajectories, are being used in the research program. The aircraft are a F-104, a KC-135, and a Learjet.

SPACE STATION ACTIVITIES

All elements of the Microgravity Science and Applications program were actively involved in Space Station planning during 1984. An interim contract was awarded for the initial development of mission requirements for the Microgravity and Materials Processing Facility (MMPF). Active involvement of the academic and industrial community was encouraged through the use of the Discipline Working Groups and various workshops. We also participated in the Office of Space Science and Applications Space Station Working Group, working closely with the Space and Earth Sciences Advisory Committee (SESAC) Task Force on Scientific uses of the Space Station Uses of Space Station, chaired by Dr. Peter Banks of Stanford University.

Additionally, preliminary mission requirements were developed for input to the Space Station Phase B activity. Management responsibility for the Microgravity Manned Laboratory was assigned to the Microgravity Science and Applications Division by the Associate Administrator for Space Station.

COMMERCIAL ACTIVITIES

Consistent with the Agency commitment to commercial use of space, we have participated actively in outreach programs to industry. We are working closely with the Office of Commercial Programs to attempt to ensure that the two programs are synergistic. The number of Joint Endeavor Agreement (JEA) proposals has increased and several are currently in the NASA review and approval cycle. Recently, Memoranda of Understanding (MOU) with the Boeing Corporation and Grumman Aerospace were signed. These particular

MOU's, both expected to lead to JEA's in the near future, highlight the importance of the NASA microgravity program to commercial use of space, in that the Principle Investigators of these proposed agreements have both long been involved and supported by the NASA Microgravity program.

The Microgravity Science and Applications Program continues to stimulate industry participation by:

1.) Creating awareness of NASA's research activities and results through publications, seminars, visits of NASA scientists to industry R&D centers, and visits by industry scientists to NASA field centers;

2.) Encouraging industry participation in joint research programs with NASA scientists; and,

3.) Encouraging private sector participation in space research by Joint Endeavor Agreements, Technical Exchange Agreements, and Industrial Guest Investigator programs.

We have also been actively involved in the study being conducted by the NASA Advisory Council Task Force on Commercial Use of Space. Preliminary findings of the Task Force have identified Microgravity Science and Applications as the area with most potential for commercial space use.

OUTSIDE PROGRAM REVIEWS

The science content of the Microgravity Science and Applications program was reviewed in detail at a workshop held in December, 1984. The workshop was conducted under the auspices of the Solid State Science Committee of the National Research Council (NRC). The formal proceeding of the workshop will be published later this year, however, initial reports are that the Committee found the program to be of great scientific merit and on a sound basis.

grow. The Microgravity Materials Science Lab at the Lewis Research Center will officially open in August of 1985. Support to Centers of Excellence will continue, with full operation of the Centers for Organic Separation and Pharmaceuticals. Programmatically, we plan to continue to build the Microgravity Science and Applications staff, both in the program office at Headquarters and at the field centers. Considerable effort will be directed towards "fine-tuning" management practices to ensure cost-effectivity and appropriate procedures.

Our Space Station activity will continue in conjunction with the Phase B studies. Mission scenarios and sets will be developed, as well as power, operations, and mission timelines. We will develop preliminary cost estimates for modification of existing STS-based hardware and development of new equipment.

We will also continue our involvement in the support of JEA's, TEA's, and IGI's, working closely with Industry to encourage their involvement and provide the benefit of our scientific and engineering expertise.

VI. SUMMARY

In closing, we are very proud of our accomplishments of the past year, and look forward to further expansion of the program, both in terms of the involvement of the academic and industrial communities and in increased STS flight opportunities, leading to wide dissemination of experimental results.

In addition, the Committee feels there is high potential for commercial benefit in the program.

V. PLANS FOR 1985

In the flight program, approximately 20 experiments are scheduled for flight in 1985. The first flight of the Materials Science Lab (MSL) is manifested for August 1985. The MSL is a specially configured facility, uniquely designed for the requirements of materials processing experimentation. The MSL provides a means for using orbiter power, as well as providing individual experiment control, heat rejection, low gravity accelerometers and data recording. An additional flight of the MSL carrier will take place in December, 1985, with 3-4 flights per year planned in 1986 and subsequent years.

The Spacelab 3 mission, scheduled for April 1985, will also carry microgravity science experimentation including the Fluid Experiment System/Vapor Crystal Growth Experiment (a multi-user facility), and the Drop Dynamics Module(DDM). The DDM was developed by the NASA Office of Aeronautics and Space Technology, but will be turned over to the Microgravity Science and Applications Program for use in fluid physics research after the Spacelab 3 flight.

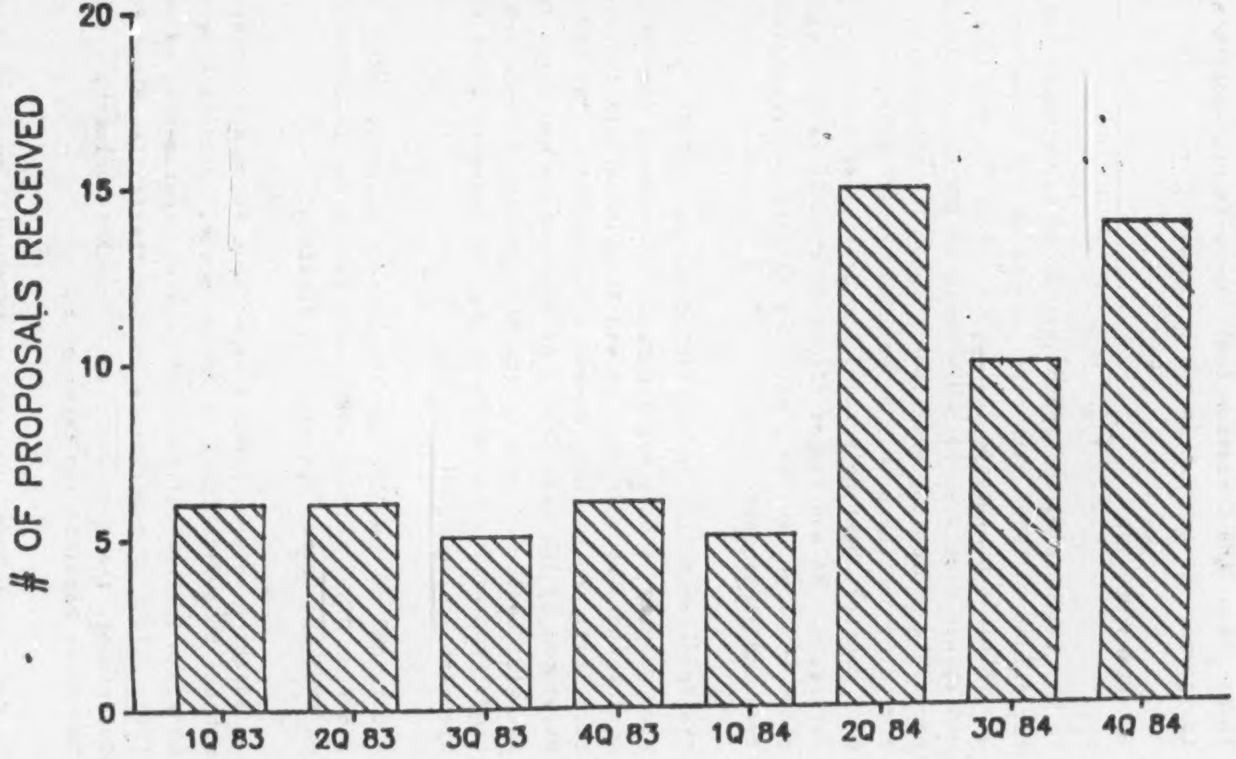
A reflight of the Materials Experiment Assembly (MEA), first flown on STS-7 in June 1983, will take place in October 1985 as part of the German Spacelab D-1 mission.

In addition several middeck experiment flights are planned, subject to availability of locker space. Middeck experiments to be flown include reflights of several experiments, as well as the first flight of experiments such as the Initial Blood Storage Experiment, the Protein Crystal Growth Experiment, and the Two-phase Partitioning Experiment.

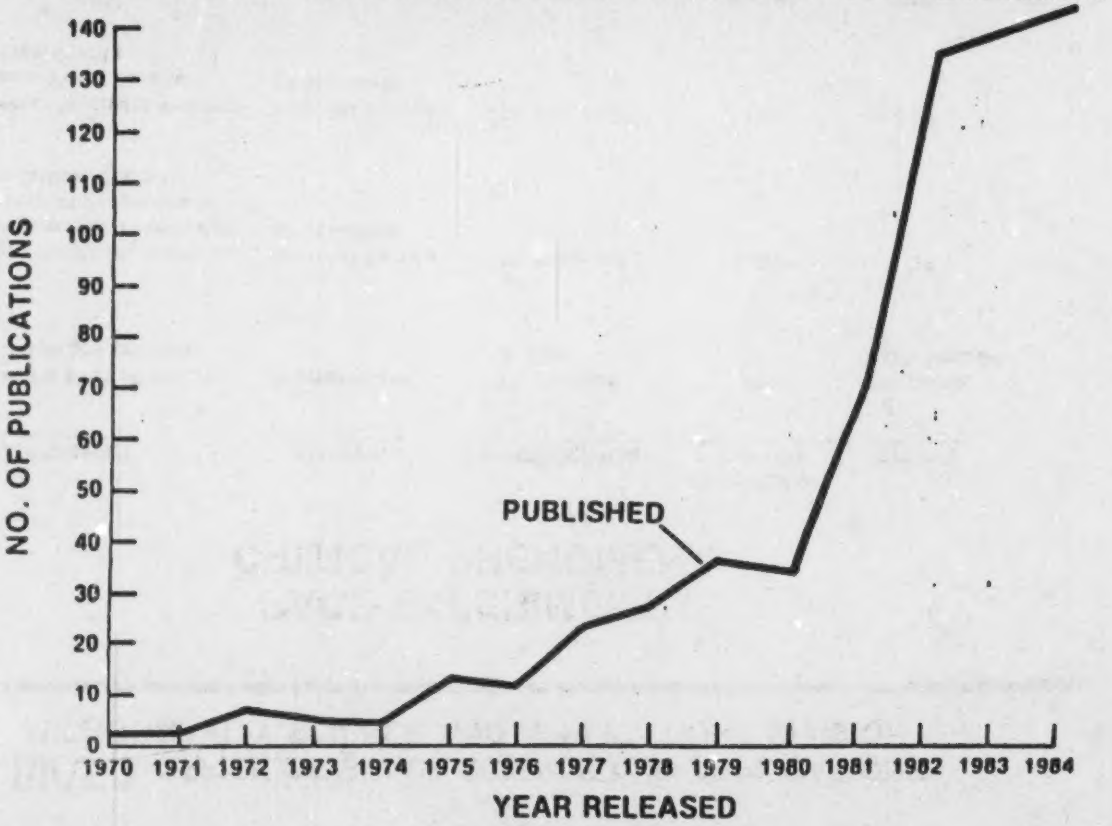
In the ground-based program, research will continue in all six disciplines and the number of proposals received is expected to

MICROGRAVITY SCIENCE AND APPLICATIONS

NEW RESEARCH PROPOSALS



SUMMARY OF PUBLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION



NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

PACE EXPERIMENTS CRITICAL PHENOMENA

EXPERIMENT	LOCATION	INVESTIGATOR	SPONSORING CENTER	STATUS
Specific Heat of Helium Through the Lambda Point	Stanford Univ.	W. Fairbank J. Lipa	JPL	SRR Comp. CoDR-Sept. 84
Light Scattering Tests of Fundamental Theories of Transport Properties in the Critical Region	National Bureau of Standards	M. Moldover	LeRC	CDP
Precise Viscosity Measurements Very Close to Critical Points	National Bureau of Standards	M. Moldover	LeRC	CDP
Critical Transport Phenomena in Fluid Helium Under Low Gravity	Duke Univ.	H. Meyer R. Behringer	GSFC	CDP

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

PACE EXPERIMENTS
FLUID PHYSICS

EXPERIMENT	LOCATION	INVESTIGATOR	SPONSORING CENTER	STATUS
Electrohydrodynamics	Princeton	D. Saville	LeRC	CDP
Surface-Tension Driven Convection Under Reduced Gravity Conditions	Case Western Reserve Univ.	S. Ostrach Y. Kamotani	LeRC	CDP
Free Surface Phenomena Under Low and Zero-Gravity Conditions	Case Western Berkeley Calif. Tech	P. Concus R. Finn D. Coles	LeRC	CDP
Surface Tension Induced Instabilities in Reduced Gravity: The Benard Problem	Univ. of Texas LeRC	E. Koschmieder A. Chai	LeRC	CDP
Mass Transport Phenomena Between Bubbles and Dissolved Gases in Liquids Under Reduced Gravity Conditions	Univ. of Toledo	K. Dewitt	LeRC	CDP
Test of New Thermodynamic Model of Impurity Extraction by Droplets	The National Bureau of Standards	G. Morrison J. Kinkaid	LaRC	CDP

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

PACE EXPERIMENTS

EXPERIMENT	LOCATION	INVESTIGATOR	SPONSORING CENTER	STATUS
		COMBUSTION		
Solid Surface Combustion	Univ. of Kentucky	R. Altenkirch	LeRC	CoDR Comp Entering FDP
Gas Jet Diffusion Flame	Science Applications	P. Harsha R. Edelman	LeRC	CDP
		RELATIVITY		
Cryogenic Equivalence Principle	Stanford Univ.	F. Everitt P. Worden	MSFC	CDP
		PARTICLE MECHANICS		
Particle Behavior Under Very Low Intergranular Stresses	Univ. of Colorado	S. Sture	MSFC	CDP

APPENDIX 15

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

AUG 28 1984

C:LN:plg

Honorable Don Fuqua
Chairman
Committee on Science and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

As requested in the House Authorization Report 98-629, enclosed is NASA's response to the NASA Advisory Council's "Study of the Mission of NASA."

If you or your staff should need any additional information in this area, please do not hesitate to contact me.

Sincerely,

Jack Murphy

John F. Murphy
Assistant Administrator
for Legislative Affairs

Enclosure

cc: Honorable Larry Winn, Jr.
Honorable Harold Volkmer

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

JUN 7 1984

Mr. Daniel J. Fink
Chairman
NASA Advisory Council
National Aeronautics and Space
  Administration
Washington, DC 20546

Dear Dan:

The NASA Advisory Council's "Study of the Mission of NASA" has been of considerable help to us in our evaluation of future program directions. Formulating the responses to the specific recommendations has required us to give much thought to the issues posed. As is evident, in most instances we concur with the recommendations and are taking actions to implement them. In some cases, we do not fully concur and the detailed response, enclosed with this letter, notes that circumstance and explains why.

We are in general agreement with the Council's summary statement of the space and aeronautics missions of NASA, and its belief in the inevitability of extensive human habitation beyond the confines of the Earth. But, just as the Council and its Task Force stopped short of identifying that as the central mission of NASA, we must stop short of establishing that as the principal goal of our space program. As we discussed during the Council meeting May 2, and as should be evident from the specific responses in the enclosure, that part of our mission that addresses exploration of the solar system, including Earth, for the ultimate benefit of humankind has a prominent place in our planning for the future. We are implementing the core program recommended by the Solar System Exploration Committee (SSEC), have begun studies of both Mars and comet sample return missions in anticipation of the SSEC supplementary report on that subject, and have begun studies of alternative programs that include human exploration and eventual utilization of the solar system and its resources.

We are taking corresponding steps in our program of "exploration" of the Earth, having established, with the Council, the Earth Systems Science Committee to help us plan the Earth Science program, and having also established a separate organization in OSSA for that program. And you are aware of our efforts to pull together the elements of a program to assess the character and trends of Earth's environment and resource elements in terms of global habitability.

Lastly, we have proposed to the Congress initiation of space station development. That station, its components and adjunct systems, and subsequent developments will form the infrastructure making possible major expansion of the preceding programs as we approach the next century. We believe these steps are fully responsive to the recommendations of the Council in solar system and Earth exploration, given the lead times inherent in space program development.

Preparing this response has also helped us to appreciate the difficulty of your task in conducting the study, so broadly defined. Having had the advantage of working on both sides of the project, I can readily appreciate this difficulty, as well as the value of your accomplishments. Please again accept NASA's thanks for a job well done, and transmit our appreciation to George Solomon, his Task Force members, and all the members of the Council.

Sincerely,

Philip E. Culbertson
Associate Deputy Administrator

Enclosure

ENCLOSURE

RESPONSES TO SPECIFIC RECOMMENDATIONS

MISSION OF NASA STUDY

1. Exploration of the Solar System, Including Planet Earth, for Human Benefit

Recommendation - The United States, in collaboration with other interested nations, vigorously pursue a program of exploration and understanding of the solar system for ultimate human benefit.

> Response - Exploration of the solar system has been a lifeblood of the Agency from the beginning and will continue to play a central role in the future as the conquest of space reaches a mature state of routine utilization. The minimum "core" program recommended by the Solar System Exploration Committee is being implemented with initiation of the Venus Radar Mapper and proposal of a Mars Geoscience/Climatology Orbiter mission. The latter is the first of a series of planetary observers, similar to the Explorers, recommended by the Committee. Also under study are possible sample return missions to Mars and a comet, missions which will soon be recommended by the SSEC as major missions to augment the core program. Lunar Base conceptual studies are being initiated, and potential uses of the Space Station to contribute to the exploration of the solar system appear to be of major impact.
>
> The exploration of the solar system will involve both automated and human activity. We cannot foresee the form that the benefits that result will take, but there have been few past instances where exploration has not led to substantial benefits within a few generations.
>
> We appreciate that the Council recognizes the benefit of pursuing this exploration goal in a cooperative spirit with like-minded nations. The recommendation to seek cooperation is most important in terms of overall U.S. foreign policy in which the value of strong allies with parallel goals is stressed. We have gained international participation in solar system exploration to date, and will continue to seek such participation in the future.

Recommendation - A more aggressive pursuit of the technologies of robotics, teleoperation, and machine intelligence be undertaken to maintain a proper lead and balance in the design of NASA programs.

> Response - We are on the verge of an explosive technical revolution in at least two major areas--the biologic sciences and machine intelligence. To remain a dominant influence in the technology development of the U.S., it is important for the Agency to take a lead in the latter area which is

directly relevant to so many of its activities. Space is a complex and fundamentally hostile environment for machines and human beings to operate in; therefore the role of the computer will always be critical. As activities in space expand, the need to amplify human capability by means of computer-operated mechanisms will inevitably grow.

Planetary exploration has been the principal driver for the development of autonomous spacecraft. To date, lunar and planetary exploration missions have been highly complex in comparison with other space missions; but they have been very straightforward in comparison with the major missions of the augmented program currently under consideration for the 1990s--Mars Rover/Sample Return and Comet Sample Return. These missions will be major drivers for further advances in the technologies associated with automated spacecraft.

Recommendation - NASA accept a leadership role in major aspects of the study of the planet Earth, in particular, in those areas which concern global changes of importance to the support of human life.

Response - NASA has already taken several steps towards this goal. These include the establishment of an Earth Science and Applications Division in the Office of Space Science and Applications and the formation of an Earth System Sciences Committee (ESSC) under the NASA Advisory Council. The ESSC, under the chairmanship of Dr. Francis Bretherton, has been charged with formulating an overall Earth sciences program plan and advising on mission priorities.

A major component of the NASA earth science program will be the Global Habitability program, which will investigate long-term coupled physical, chemical, and biological changes in the Earth's environment on a global scale (atmosphere, land, oceans, and biosphere). The scientific basis for this program has been formulated through a series of workshops and meetings, and is currently being reviewed by the National Academy of Sciences.

This program will be comprised of disciplinary and interdisciplinary research involving space-based, suborbital, land-based, and sea-based measurements, as well as laboratory, theoretical, and instrument development studies. It will be conducted as a cooperative program involving other domestic and international organizations. The Global Habitability program will be implemented within NASA by continuing, and expanding where necessary, ongoing programs which are relevant; by refocusing related research activities; and by initiating new interdisciplinary research in air-sea, land-air, and land-sea interactions and biogeochemical cycles. Satellite systems, such as Landsat, the Upper Atmospheric Research Satellite (UARS), the Ocean Topography Experiment (TOPEX), and the Navy Remote Ocean

Sensing System (NROSS) scatterometer, will be used to support the data needs of the Global Habitability program.

Recommendation - Adequate funding be provided for ground-based, laboratory, and theoretical work, as well as for space systems.

Response - In recent years, the Agency budgets for research and analysis and mission and data analysis have been increased in recognition of this need. This recognizes that the Solar System Exploration Program requires a major support effort in the areas of ground-based, laboratory, and theoretical work, in addition to the development of space systems. These efforts are needed to provide the base of knowledge demanded for solar system exploration. The supporting research efforts are an integral part of NASA's planetary exploration program and, as such, are both a foundation and a framework for the exploration effort.

Recommendation - NASA seek a lasting national commitment in order to achieve these goals, which will require new approaches to project procedures and budgetary procedures including steady funding levels and program continuity.

Response - NASA is doing so within the present legal constraints. Within the context of the annual budget process, the Agency has demonstrated its commitment to planetary exploration as evidenced by the initiation of the Mars Geoscience/Climatology Orbiter, the first planetary observer mission, in FY 1985. The planetary observer concept will be pursued for potential future missions. The new approaches recommended by the Solar System Exploration Committee are being applied and planning is being conducted under the assumption that a viable and exciting program of solar system exploration can be conducted with a steady, assured funding level. Our goal in the Earth Science and Global Habitability programs now under development is to achieve at least the same level of commitment as has been achieved in solar system exploration.

2. Fundamental Space Science

Recommendation - Space science must remain a principal part of NASA's mission because research in space science has become a central element of scientific research in the United States and prospects for future major advances in this field remain bright.

Response - NASA's goal is to maintain a strong science component in the future. Space science activities have historically been an essential part of NASA's space missions to explore both the outside universe and the global features of our own planet Earth. In the past, new space systems have provided new capabilities for scientific studies, while the resulting scientific discoveries have not only extended our knowledge but have also identified new technological needs. We intend this productive interrelationship to continue in the future, science being an integral part of our overall planning. In particular, we are actively considering such topics as the effective use of new technical capabilities (Space Shuttle, Space Station) for scientific studies and more sophisticated scientific attacks on remaining major problems about the Earth and the universe (such as those studies recommended by the Astronomy Survey Committee of the National Academy of Science and the Solar System Exploration Committee).

Recommendation - Adequate and stable levels of funding for ground-based, laboratory, and theoretical research, a key part of NASA's scientific program, be provided independently of the fluctuating needs for spacecraft and instrument construction.

Response - Maintaining a stable program of ground-based research will continue to be an essential part of NASA's future activities. We feel strongly that past ground-based research has contributed to the success of missions in several ways: (1) by identifying major scientific problems and defining future missions; (2) by supporting the planning, design, operation, and data analysis of actual missions; and (3) by providing important scientific results that cannot be obtained from spacecraft. An assured stable level of support for ground-based activities is essential for the health, stability, efficiency, and continuity of the much-needed research effort and to insure that new technological developments are adequately and efficiently used for scientific studies. We are working to examine how such stability can be established. One example is the recent report of the Solar System Exploration Committee (SSEC), in which a stable research program is specifically cited as an essential part of a successful program of future planetary exploration. The NAC's Space and Earth Science Advisory Committee has formed a research and analysis study group to address the same issue across all the space science disciplines.

Recommendation - NASA take a lead role in assuring that the activities sponsored by NASA and NSF are properly coordinated.

Response - NASA endorses the view that coordination of scientific funding and management between different Federal agencies is needed for the effective progress of science and for the efficient use of Federal funds. Effective coordination mechanisms are in place and working well; and NASA will work to strengthen existing coordination mechanisms and establish new ones where necessary.

NASA personnel meet with equivalent NSF personnel in informal discipline-oriented interagency working and discussion groups, especially in such fields as plasma physics, chemistry, and geophysics. In addition, individual NASA and NSF program managers coordinate their activities and exchange information in areas where both agencies are involved, e.g., astronomy and meteorite research. We feel that these kinds of coordination have proven effective in carrying out NASA's and NSF's separate responsibilities in science. We plan to take an active role in continuing these contacts, and we will make special efforts to strengthen existing coordination mechanisms and to establish new ones as it becomes necessary.

3. Space Technology

Recommendation - NASA's mission in space research and technology be supportive of total national requirements, considering future needs of the civil, military, and commercial sectors. In terms comparable to those for NASA's mission in aeronautics, NASA should have the mission in Space R&T to:

- Fund, direct, and implement space research, technology, and demonstration programs in support of its own and other civil space activities; and support DOD technology needs where the results have broad application and are not duplicative of other government-funded effort.
- Encourage and facilitate, together with other appropriate agencies, the transfer of Space R&T results to and within U.S. industry.
- Manage, maintain, and operate space research, development, test, and evaluation facilities. Use of the Space Shuttle and eventually a space station as a laboratory facility in space should be exploited for development of new space technologies.

Response - NASA concurs with the broadened Space R&T mission recommendation of the Task Force. We agree that the NASA/industry relationships that have developed over the years in Aeronautical R&T provide a reasonable model for the Space R&T program serving the needs of the civil, military, and commercial sectors.

By focusing the R&T Base program on a more selective range of technology programs, NASA will, within its areas of recognized strengths, increase its support to needs of the civil and commercial sectors. As funding permits, NASA will also undertake to support, in a non-duplicative manner, high priority needs of the military in space such as those for orbit-on-demand and transatmospheric vehicle systems. We also intend to follow specific recommendations of the ASEB Woods Hole report in pursuing spacecraft bus technologies.

As the Space Technology program is broadened in scope, we intend to encourage greater involvement and participation by industry and the university community. We will strive to increase joint interagency planning, cooperative programs, contracts, grants, and cost-sharing agreements.

NASA will, as recommended, continue to place a high priority on the management and operation of space research, development, and test facilities. We will seek to sustain these national resources in areas of recognized capability and support them with the best personnel available and the most current equipments. The use of Shuttle, and later space station, offers a national asset for space-based research which we agree must be pursued aggressively. NASA's Space R&T program will give high priority to expanding the use of Shuttle as a platform for in-space research experiments. Reusable experiment platforms will be developed to provide ease of integration with the Shuttle and lowered cost of space technology research. The space station will provide continuing and substantially expanded opportunities for space-based research and extensive planning is already in progress. The participation of other government, industry, and university researchers will be actively sought.

Recommendation - Funding for NASA Space R&T be increased selectively to permit implementing these recommendations. The following criteria are suggested for identification of technologies to be accorded high priority:

- The technology is in the national interest and will fill a reasonably established future requirement.
- The technology offers payoff significantly greater than that presently available at a reasonable cost and is at least comparable in payoff and cost to alternative approaches to the same end.
- The technology program is not likely to be undertaken, on a timely basis, by others, either public or private.
- The technology is in an area in which NASA already has a demonstrated capability, or if in a new area, is one in which NASA can readily build the capability and expertise without duplicating an equivalent capability outside.

Response - We agree with each of the four stated criteria for selectively increasing NASA Space R&T funding in high priority technology areas.

NASA has recognized areas of expertise in which it can provide high leverage payoffs to national programs. We will continue to conduct critical assessments of these capabilities to ensure that both focus and high standards of excellence are achieved. The NRC's ASEB, our subcommittees of the Space Systems Technology Advisory Committee, and other ad-hoc teams of industry, university, and government peer personnel will provide continual critique and counsel. There is a growing consensus regarding the following areas of NASA expertise and national need: large flexible, precision controlled structures; space power and thermal management; propulsion systems; materials; man-machine interaction and automated systems; and environment definition.

Areas in which NASA is deemed capable of "readily building capacity and expertise" are also being identified and evaluated. The establishment of a national capability for in-space technology research is the outstanding example. Another area of high potential is space environmental modeling and simulation in which NASA has recognized capability, i.e., space plasma, atomic oxygen, and particulate contamination. A greater investment of resources would be required to provide a nationally recognized source of knowledge, test capability, and expertise. It is intended to affirm or alter these tentatively selected areas of focus over the next year and to generate detailed plans at our field centers for their implementation.

Recommendation - Funding augmentations in high priority technologies be provided only after reasonable assurance that ongoing technology developments of little potential value are being phased down and that a base level of more basic research is being maintained across the full spectrum of disciplines to assure that new technology opportunities applicable to future missions are not missed.

Response - We accept and will act appropriately on this recommendation. We most strongly concur in the need to stress more basic (long-range) research. We intend to maintain awareness across the full spectrum of disciplines to assure that new technology opportunities applicable to future missions are not missed. However, we propose to differentiate in our management strategy between areas of resident (in-house) and non-resident (out-of-house) expertise. It is our intent to make the resource commitments to those areas of nationally recognized capability and to reduce those areas where we can acquire or exploit, through more modest investments, technology advances being made by others.

More specifically, based on preliminary consensus, we will seek to capitalize on external capabilities in electronics device technology, sensing and detection devices, and data management. It should be recognized that a knowledgeable resident capability is needed to assure the successful transition of external capability to NASA's future mission needs. In order to retain such capabilities at our centers, personnel must be supported with a sustained, modest level of research activity and facilities. During this coming year, we will ask our center management to confirm these areas of external expertise and to generate implementation plans.

4. Space Applications

Recommendation - The NASA mission include the study of space and space technology for civil applications, by: continuing the identification of possible civilian applications of potential value and by conducting preliminary studies of potential benefits, users, and markets.

> Response - Such studies are a continuing part of the NASA Space Science and Applications program. Current studies of this nature include large geostationary communications platforms, materials processes in microgravity for industrial applications, and remote sensing of the solid Earth surface, oceans, and atmosphere for environmental and resources purposes.

Recommendation - by: taking the leadership (with interested appropriate agencies) in systematic reviews of existing and possible civil applications of space with the formal involvement, in an advisory committee structure, of selected participants from the prospective users and providers of services in the private, public, and academic sectors; the pertinent scientific, technical, and industrial communities; and the interested civil and defense agencies of the Federal government. The purpose of the reviews is to identify requirements and priorities for research, technology development, test and demonstration, user experimentation, and market development.

> Response - NASA does so. One mechanism is through program reviews of the Space Applications Advisory Committee (SAAC) and its subcommittees responsible for communications, remote sensing, microgravity research, and earth sciences. A separate advisory group is planned to fulfill these same functions across the spectrum of potential commercial applications.
>
> NASA also participates in a number of interagency activities concerned with space applications. Among them are: NASA/NOAA activities on weather prediction, NASA/EPA studies on acid rain, NASA/AID activities in remote sensing, and NASA/DOI remote sensing support for forestry.
>
> NASA cooperates in many applications research projects with other organizations, including Monsanto; International Paper; Marine Fisheries; Corps of Engineers; Pacific Gas and Electric; Woodward and Clyde; States of Alaska, Florida, and Idaho; Department of Agriculture's Soil Conservation Service; United Nations' Man and the Biosphere Program; and a number of universities. Through involvement with these types of organizations representing different sectors, NASA maintains a close awareness of potential civil applications, and their related benefits, users, and markets.

Recommendation - by: conducting or supporting research and technology development on essential components and subsystems of space and ground systems for civil space applications, where such research and development is not being, and cannot reasonably be expected to be, conducted and paid for by the private sector or by the Department of Defense or another government agency.

Response - NASA's applications research and development (R&D) program is centered on such work. In communications, NASA does basic research and technology development, but only the minimum necessary to get industry to pick up the R&D. In microgravity research, the objective is to investigate the zero g behavior of materials in a fluid state and identify processes that exploit the unique character of the microgravity environment so that the industrial research community will find sufficient merit to pursue commercial ventures. In remote sensing, present efforts are concentrated on Earth science, to understand better how solid Earth, ocean, and atmospheric parameters sensed remotely can be employed for analysis and prediction of real phenomena. Systems to provide data access and processing services are being developed, exploiting recent information system technology advances.

Recommendation - by: conducting, with suitable cooperative arrangements with the private or public agencies, tests, demonstrations, and experimental user operations of new types of spacecraft, spaceborne systems, and ground systems for civil space applications in cases where:

- Potential advantages, uses, and users have been identified.
- The private sector or other agencies cannot reasonably be expected to pay the full cost.

Administration recognition of this mission of NASA should be sought.

Response - NASA pursues this approach when possible. Examples from the past are the Applications Technology Satellite (ATS) programs and Landsat. Recently an Advanced Communications Technology Satellite (ACTS) program was initiated in this way, but it was changed to a ground-based technology program when a commercial firm indicated plans to cover some of the technology in a flight project. A joint program with industry for mobile communications via satellite is under consideration. Remote sensing projects to measure ocean parameters (Ocean Topography Experiment (TOPEX) and the Scatterometer instrument) are also under study. Pilot systems for remote user access to data sets and processing services are under development (e.g., Pilot Oceans Data System, Climate Data System, and Landsat Data System).

Recommendation - by: arranging for the transfer of useful applications systems employing space technologies to private or public agencies as appropriate; unless it is in the national interest for NASA to become the operating agency.

> **Response - This is the major goal in each applications program and has been successfully completed for weather satellites (NOAA), communications satellites (private sector), and Earth sensing satellites (NOAA).**

5. Space Transportation System Operations

Recommendation - A new NASA organization be created at the appropriate time within NASA to focus on Shuttle operations and utilization, including marketing activities and sustaining engineering support. This organization, which should be headed by a Deputy Administrator, should have fenced manpower, finances, and facilities.

> Response - The Shuttle has not yet reached a fully operational and stable status. Still to be accomplished are: completion of the 4-Orbiter fleet and modifications to Columbia, completion of ground support and launch site equipment, implementation of the full maintenance and spares program, development of acceptable design life for the main engines, and standardization of the cargo/Shuttle interfaces. NASA has begun heading in the direction of separation; a new budget structure for FY 1985 separates operations and production from the rest of NASA R&D and launch processing contracts at KSC have been consolidated. If full separation is later appropriate, these steps will pave the way. Whether any separate organization would be headed by a "Deputy Administrator," elevating that office above the R&D organizations, is not clear, but will be considered when appropriate.

Recommendation - The Shuttle operations organization continue to enhance customer service and market development activities through the application of resources both internal and external to NASA as appropriate. Consideration should be given to contracting out the market development activities.

> Response - Market development is a major effort in NASA. Proposals to assist NASA with the marketing, sales, and customer service activities for the STS are being sought from industry, with a Request for Proposal scheduled for release in the summer, 1984.

Recommendation - The Deputy Administrator for Shuttle Operations be charged with proposing the evolutionary steps for future management of Shuttle operations.

> Response - The position of Assistant Associate Administrator for Space Shuttle in the Office of Space Flight was established February 7, 1984. This official will have responsibility for development and production of Orbiters, main engines, solid rocket boosters, external tanks, and ground support equipment; and for flight and turnaround operations of these elements as a transportation system. When this official is on board, he will participate fully in the development of subsequent management changes.

Recommendation - The Shuttle operations organization not undertake future STS development activities, such as a follow-on

Shuttle or new launch capability, but should help define requirements for such major improvements.

> Response - This is implicit in the present Space Flight organization, where advanced projects studies are separate from Shuttle development, production, and operations. The first priority for the Shuttle is to make it simple and easy for the customer to use, essential as payloads become more complex and interactive. The second priority is to address the problems keeping us from making the Shuttle fully operational, as noted previously.

Recommendation - The value of the STS as a national resource due to its unique capabilities to provide for manned spaceflight, defense missions, space science support, and research and technology in the space environment, as well as its special capabilities for satellite retrieval and spacecraft servicing, be recognized. The total costs associated with this national resource value should not be charged to the Shuttle's launch service users.

> Response - The present policy, fixed thru 1988, charges commercial and foreign customers the total average cost of consumables plus a portion of fixed costs. The policy for the post-1988 period is under study, and will include consideration of the national resource value (i.e., how much of fixed costs should be charged to those users).

Recommendation - As markets for the STS develop, NASA consider shifting pricing of Shuttle services towards an incremental (i. e., institutional) cost basis. This is the usual practice in NASA research facilities and, given the national resource character of the Shuttle for civil and military government programs, is more appropriate than pricing on the basis of total recovery of recurring costs (industrial funding).

> Response - The policy for launch pricing for the post-1988 period is under study (see preceding).

6a. Aeronautics

Recommendation - NASA's mission in aeronautics include, subject to specific approval, support to the industry in civil aviation technology demonstration programs provided that they are in the national interest, the industry cannot effectively conduct the programs without that support, and the support fits naturally within NASA's capabilities.

> Response - At the present time, the OSTP Aeronautical Policy Study of 1982 has in effect specifically precluded NASA from engaging in R&D activities which are categorized as "civil aviation technology demonstration programs." This is one aspect of the 1982 OSTP study which the Office of Management and Budget rigorously supports. NASA has chosen, for the present, not to argue the case further since it is considered to be of greater importance to aeronautics to assure that sound R&T base programs are not jeopardized. Instead, NASA has placed emphasis on close collaboration with DOD in areas where a common technology goal is apparent for both civil and military aspects. However, in order to keep this important issue alive, NASA will propose to the OSTP Aeronautics Policy Implementation Committee at its meeting in 1984 that another look be taken at the restrictive effect which a continuation of the present policy will have on the development of civil aviation in the U.S.

Recommendation - NASA continue to assist, communicate with, and cooperate with all branches of the DOD in all matters relating to aeronautics. The first priority should be in R&T areas of the basic technologies of aeronautics and should include providing access to and utilization of both human resources and laboratories and other physical test facilities as appropriate. The second priority should be in mission-oriented systems work as requested, or when special expertise or facilities are available.

> Response - NASA will continue to give assistance to and communicate with all branches of the DOD in all matters relating to aeronautics. The Agency believes that its present mechanisms, which include formal coordination through the Aeronautics Panel of the AACB, exchange of liaison and technical personnel at the Headquarters and Field Center/Laboratory level, specific biannual technical coordination meetings between NASA Centers and DOD Laboratories, and the very close day-to-day working relationships which exist at the technical level, is unmatched by any other coordination mechanisms which exist within the government. NASA R&T in the basic areas of aeronautical technology is tightly woven with DOD's, and we will continue to give attention to the needs of DOD and their contractors through the use of our facilities and expertise. In the more mission-oriented systems work, we are also applying our unique capabilities at the Dryden Flight Research Facility through direct involvement with the Air

Force, Army, and Navy in such joint programs as AFTI-16, AFTI-111, F-14, X-29, X-Wing, and Convertible Engine, to note just a few. We interd to continue this successful, cooperative arrangement.

Recommendation - Continue to strive for excellence in basic technologies of aeronautics.

- Establish, build up, and nurture "centers of excellence," (the quality of people employed is critical to the success in this area).
- Establish, provide, and keep up-to-date physical resources, i.e., laboratories and test facilities uniquely capable of supporting the technologies.

Response - NASA is continuing within the limits of personnel ceilings to assure that the best of the available young talents are sought in order to bolster key aeronautical research activities at such "centers of excellence" as computational fluid dynamics and rotorcraft at Ames, engine materials at Lewis, and structures and advanced military configuration research at Langley, to note a few.

The Agency recognizes the key role which the unique aeronautical facilities play and will continue to make significant efforts to keep these facilities up to date and to add additional capabilities as a national need arises. Recent examples of trends in this direction are the major thrust to bring on-line the most advanced fluid dynamics computational capability at Ames, tne Numerical Aerodynamic Simulation project, and the plan to expand the high Mach number real air propulsion test capability of the Langley 8-Ft. High Temperature Structures Tunnel.

Recommendation - Continue to provide an advisory committee structure to promote communications between NASA and DOD, as well as with industry and academe.

- At top management levels of the respective organizations to monitor overall planning and performance.
- At working levels to be certain of continuing detailed technical communication. This should be in both directions.

Response - The present NASA advisory committee structure in Aeronautics consists of an Aeronautics Advisory Committee supported by ad hoc subcommittees on Aerodynamics, Materials and Structures, Aeronautical Propulsion, Aircraft Controls and Guidance, General Aviation, Rotorcraft, Safety and Operating Systems, Transport Aircraft, and High Performance Aircraft Systems. The military services are represented on all subcommittees except General Aviation and Transport Aircraft. Possibly more importantly, the aircraft industry, which conducts a very significant fraction of DOD R&D, is represented heavily on all subcommittees and on the Aeronautics Committee. Top-level management officials from DOD and the industry are selected for membership on the committees. Also, as mentioned previously, formal coordination is effected through the Aeronautics Panel of the AACB. There are numerous formal working level committees established between DOD agencies and NASA in areas such as flight research, simulation, and low observables, and increasing use is planned to be made of such approaches.

Recommendation - Be prepared to work in classifed areas when appropriate. This will probably be a requirement to be effective in mission-oriented systems areas.

Response - NASA has and will continue to work on specific and generic classified areas of aeronautical technology both in direct response to military requests and independently in areas where NASA expertise is expected to lay the groundwork for future military mission-oriented systems activities. Such activities represent a significant investment of NASA R&D funds and personnel.

6b. Human Spaceflight Research

Recommendation - NASA give high priority to the continuing program needed for the development of this capability (for safe and productive long-duration space flight for humans). Of special interest at this time is research associated with problems of exposure to zero gravity; provision of supportive ambient conditions with special attention given to oxygen, food, and water; provision of an adequate social and organizational environment; exposure to ionizing radiation; and extravehicular activities.

Response - The FY 1985 Life Science Program is proposed to increase by about 8 percent over that for FY 1984. In addition, it is expected that some funding will be allocated for life science research and development (R&D) from the Space Station Program to emphasize issues associated with human safety and productivity.

6c. International Relationships

Recommendation - NASA take the steps necessary to ensure greater awareness within the government of its value and that of its aerospace programs as an instrument of U.S. foreign policy.

> Response - NASA has been working closely with the White House and the State Department to emphasize the value of its international aerospace programs to U.S. foreign policy goals, and it will continue to pursue this effort vigorously. The President's recognition of international participation in space station activities in his State of the Union Address is a major success in highlighting this important role for NASA. This new initiative, which the President also plans to feature at the coming Economic Summit in London, should considerably enhance the awareness within and without the government of NASA programs as valuable U.S. foreign policy assets.

Recommendation - Cooperative agreements between NASA and foreign or international agencies be developed and maintained consistent with long-term foreign policy objectives as well as with scientific and technological objectives to achieve a greater degree of constancy and stability.

> Response - NASA's international cooperative agreements represent "best-effort" commitments on the part of all the signers. It has always been our intent to maintain both constancy and stability. While much has been made of the decision to delete the U.S. spacecraft from the International Solar Polar Mission, this step was taken only after careful deliberation. Moreover, it is the only case over a twenty-five year period where NASA has been required to follow such a course, although we have been a party to literally hundreds of international agreements. We fully understand the necessity to be good partners in all our international undertakings, and we are committed to that end.

APPENDIX 16

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

C:LWH:mdd AUG 13 1984

Honorable Don Fuqua
Chairman
Committee on Science
and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

In the report 98-629 which accompanied the FY 1985 NASA Authorization Bill, the Committee requested that NASA take a leadership role in identifying the cause of and solutions to the persistent solid rocket propulsion problems that have occurred recently. Consistent with the intent of your request and since there is a nationwide lack of basic engineering knowledge on solid rocket motors, NASA is planning to undertake work in this area. We believe that this work is necessary in order to minimize the impact of the PAM failures on the STS schedule. This effort is urgently needed because we are now flying upper stage rocket motors that are not well understood and we have large number of motors forecast for the near-term missions. This country's ability to conduct planned space missions is highly dependent upon the availability of large numbers of highly reliable solid rocket motor upper stages.

We are proceeding with a two-phased program. The first phase will address potential near-term improvements for systems now flying. The second phase will generate a sound engineering data base applicable to the broader range of solid rocket motors. Our program is based on the findings of technical experts from within NASA, DOD, and U.S. industry.

NASA is reallocating approximately $3 million within the upper stages program for FY 1984 to initiate this effort because of the urgent need for early solutions. A further adjustment will be required in FY 1985 to make the necessary additional resources available. The specific amount for the NASA share of the effort will depend upon the outcome of our consultations with the DOD and industry for funding and support, but we project a total requirement for NASA funding over the next several years of about $13-15 million.

We will keep you advised of our progress and activities in this area.

Sincerely,

John F. Murphy
Assistant Administrator
for Legislative Affairs

cc:
Honorable Harold L. Volkmer
Honorable Larry Winn, Jr.

APPENDIX 17

NASA
National Aeronautics and
Space Administration
Washington, D.C.
20546
Office of the Administrator

OCT 11 1984

Honorable Don Fuqua
Chairman
Committee on Science
and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

Pursuant to the House Authorization Report 98-629, we are proceeding with a number of priority orbiter improvements/ modifications. There are also a number of enhancements which we are now examining for later implementation. A listing of these changes and enhancements is provided in the enclosure.

Sincerely,

James M. Beggs

James M. Beggs
Administrator

Enclosure

cc:
Honorable Harold L. Volkmer
Honorable Larry Winn, Jr.

Orbiter
Improvements/Modifications
Underway or Approved

Description	ROM Costs ($ in Millions)
Wing modifications to OV-104/OV-103 (completion - April 1985 and mid-1985, respectively)	6
Centaur modifications to OV-104 and OV-099 (completion in April 1985 and mid-1985, respectively) - for planetary missions in May 1986	39
Operational modifications to OV-102 (completion in January 1985)	44
Installation of fifth cryo set modifications in OV-104 (completion in April 1985) - for longer duration missions	7
Improved auxiliary power unit (available for flight mid-1987) - improved reliability, maintenance and life	25
Improved landing gear system (some improvements currently available) - solve current problems.	3

Orbiter Enhancements
Potential Future Implementation

Description	ROM Costs ($ in Millions)
General Purpose Computers	33
Inertial Measurement Units	17
Mass Memory Units	6
Star Tracker	23
Recorders	6
Closed Circuit Television	12
Global Positioning Satellite Receivers	37
Recyclable Carbon Dioxide System	12

Specific estimates and schedules for these enhancements have not been developed. However, if undertaken, most items would not be available until the 1987-1988 time frame.

Enclosure

APPENDIX 18

NASA
National Aeronautics and
Space Administration
Washington, D.C.
20546
Office of the Administrator

NOV 15 1984

Honorable Don Fuqua
Chairman
Committee on Science
and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

The enclosed report on the Government Use of Expendable Launch Vehicles is submitted in response to the Committee on Science and Technology request contained on page 21 of the report 98-629 which accompanied the FY 1985 NASA Authorization bill. NASA has reviewed the current and future use of expendable launch vehicles and their impact on the Shuttle. The results of that review have been summarized in the enclosed report.

Sincerely,

James M. Beggs
Administrator

Enclosure

cc:
Honorable Harold L. Volkmer
Honorable Larry Winn, Jr.

GOVERNMENT USE OF EXPENDABLE LAUNCH VEHICLES

Introduction

Currently there are two major areas of activity involving government use of expendable launch vehicles. The first area involves the near term use of ELVs that perform within the existing Shuttle launch capability. This includes both commercial operators potentially taking over NASA expendable launch vehicle programs being phased out by the government as launch requirements are transitioning to the Space Shuttle and the development of an improved DOD ELV. The second area involves potential government development of a new generation of ELV's augmenting the Shuttle by providing extremely heavy lift capability. These ELVs will be required for major missions having capability requirements exceeding those of the Shuttle.

Near Term Commercial and DOD ELVs

President Reagan, in his National Space Policy of July 4, 1982, and in his State of the Union Address of January 25, 1984, made the expansion of private investment and involvement in space a major objective of the United States Government. The Policy requires that government and industry work together to ease regulatory constraints and promote private-sector investment in space, including the development, production and launch of ELVs. The policy directs NASA to coordinate and facilitate the transition and operation of existing ELVs when government requirements for these programs are completed. The National Space Policy also directs that the Shuttle is a major factor in the future evolution of the U.S. Space Program and specifies that the Shuttle is to be the primary launch system for both U.S. National Security (DOD) and civil government (NASA/NOAA) missions.

Consistent with this policy, NASA has proceeded to phase out its current ELV systems, while at the same time implementing national policy to commercialize ELVs as outlined in President Reagan's NSDD-94, dated May 16, 1983. Initially, commercial operators were interested in two of NASA's ELVs for commercial operations - the Delta and the Atlas-Centaur. Recently, another commercial company has expressed interest in Scout. Proposals for commercialization of Delta and Atlas-Centaur vehicles have been solicited, received and reviewed, and a single operator selected for each vehicle. Negotiations have been in progress for some time, with a goal of establishing commercial operations as soon as possible. In fact, an interim agreement was signed with Transpace Carriers Inc., in early 1984 to establish credibility and initiate marketing of the Delta. The commercial operator interested in Scout has not yet requested the start of such negotiations.

It was NASA's understanding that the DOD was in a similar process of phasing out its expendable launch vehicles. However, during the FY 85 Congressional budget cycle DOD expressed a need to maintain an ELV capability at a level of two upgraded ELVs per year for five years, beginning in FY 1988. The DOD indicated that while they consider the Shuttle to be their primary means of launch, they believed that they needed a complementary ELV capability. While we believe the Shuttle can meet all current DOD needs, NASA does not question the DOD's requirements, but believes that the best means of providing this capability is through the use of a Shuttle-derived launch vehicle which will use the latest available technology, help us progress to a heavy lift launch capability which is necessary to meet DOD requirements in the 1990s, reduce the necessary manpower which would be required to operate two separate launch systems, and save money for the taxpayer.

The Space Shuttle fleet of four Orbiters together with the related investment in tooling, equipment and facilities, is based on a planned capability to conduct twenty four flight missions per year. The total planning and budgeting have been based on projections that about one third of these missions would be used by DOD, and another third would be used by commercial users. Because a substantial portion of the total cost of providing the Shuttle capability is not readily variable with changes in flight rates, if DOD and commercial payload missions do not materialize, and the actual reimbursements fall below projections, the requirement for Shuttle operations funding from direct appropriations to NASA is increased. As a rough approximation, the net effect of dropping a reimbursable mission from the flight plan is an increase in the NASA funding requirements of $25M to $50M, depending on timing of decision and other factors. Decisions on flight plans by the DOD have a direct and major impact because the significant variations can occur in response to dynamically changing requirements and many of the payloads require full dedicated Shuttle missions. Decisions by commercial customers can have a similar effect, although the impact of any given decision is generally less because most commercial customers involve only partial Shuttle payloads.

Competition from commercial ELVs, including those developed to meet DOD requirements, could also have a potential impact on the Shuttle. While it is premature to judge the probability of success of commercial ELV programs, the potential impact of reduced Shuttle flights for reimbursable customers on NASA's direct appropriations requirements becomes increasingly critical as the Shuttle flight rate capability increases. This problem is exacerbated as the Shuttle price approaches full operating cost recovery. The budget with full cost recovery is constructed on the basis of reimbursable customers contributing a pro rata, and, therefore, significant portion of the systems fixed costs. As these flight requirements are reduced, the reimbursements are lost while the fixed costs remain, resulting in an increased requirement for direct appropriations.

Heavy Lift Capability

The second area of potential ELV activity concerns future long-range DOD requirements for heavy lift capability exceeding that of Shuttle. NASA believes that the obvious candidate to meet these requirements is a Shuttle-Derived Launch Vehicle (SDLV) which takes advantage of Shuttle technology. This approach would maximize the options for future growth as well as minimize the development costs since much of the basic development has already been done for Shuttle.

Similarly, operational savings could be achieved to the extent that an SDLV utilized Shuttle elements. For example, use of Shuttle launch team and launch facilities would spread overhead costs over a greater number of missions thereby reducing the unit cost per mission and the total direct appropriations required for launch support of government missions.

There are indications that DOD may come to agree with NASA that a lift capability in the 150,000 pound regime will be needed in the mid-1990's and that such a launch vehicle would employ Shuttle hardware and facilities.

APPENDIX 19

NASA
National Aeronautics and
Space Administration
Washington, D.C.
20546
Office of the Administrator

NOV 21 1984

Honorable Don Fuqua
Chairman
Committee on Science
and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

As part of its Report accompanying the FY 1985 NASA Authorization bill (House Report 98-629), the Committee requested that NASA submit a report on the costs and technical aspects of undertaking the development of an Extended Duration Orbiter (EDO). In response to this request, NASA has re-examined the potential need for an EDO, including the cost, schedule and technical impacts of mission durations of 10-20 days, and, of greater than 20 days. A summary of the results of this examination is enclosed.

Our analysis, to date, indicates that it would be very difficult to justify the large expenditure of funds, and major control and avionics changes which would be necessary to extend the duration beyond 20 days, when there are no identified critical requirements for that capability which could not be met more effectively by the Space Station. The data gathered for durations beyond 20 days indicate a cost of over $1 billion with a moderate to high technical risk, depending on the approach taken. The effort would require approximately four years, and would entail substantial changes to the Orbiter systems and payloads. The systems' changes could be severe enough to require an Orbiter to be dedicated to only extended mission, thereby causing a significant impact upon fleet size. These impacts are displayed in the enclosed charts.

For extended missions of less than 20 days, we have identified several areas in which missions of approximately 14 days would have utility: vapor and solution crystal growth, high thermal gradient growth crystals, developmental biology, cosmic ray detection, solar data during an entire pass and full earth coverage from polar orbit. Two additional potential uses have recently been suggested: developing greater experience in Spacelab missions which might provide insight into Space Station operations, and providing several additional days of Shuttle on-orbit time during Space Station assembly operations. While the cost of Shuttle modifications to permit mission durations of between 14 and 20 days is considerably less than for missions beyond 20 days, they are still substantial. They also require development periods of 2 1/2 to 3 years, and result in other restrictions in Shuttle capability. Depending on the particular modifications, these restrictions on other aspects of Shuttle performance include payload weight, dimension and c.g. limitations, attitude constraints, field of view restraints, storage restrictions and turnaround time.

The approaches considered for both plus 20 and less than 20-day capabilities are illustrated on the enclosed configuration option chart which also shows their relative costs, uses and development times.

We are currently installing a fifth cryogenic tank set kit in the Atlantis vehicle, now undergoing final assembly in Palmdale, California. This kit extends the on-orbit capability to approximately ten days. Orbiter Columbia also has this capability, and was utilized to provide additional mission duration for the first Spacelab flight.

We believe this cryo kit capability meets our requirements for the foreseeable future, and that at the present time, requirements for an EDO of 10-20 days are small, and do not warrant the development of this capability. Thus, we have no plans to develop an extended duration orbiter at this time. We shall continue to search both for potential benefit from extended missions and for economical means to achieve mission extension to the orbiter's current capability. In the event that we find a basis for changing our current position, we shall, of course, recommend that such a program be undertaken.

Sincerely,

James M. Beggs

James M. Beggs
Administrator

Enclosure

cc:
Honorable Harold L. Volkmer
Honorable Larry Winn, Jr.
Honorable Manuel Lujan

EXTENDED MISSION DURATION

EXTENDED MISSION DURATION CONFIGURATION OPTIONS

	CRYO WAFER KIT	POWER EXTENSION PACKAGE	SOLAR ARRAY BATTERY EDO	25KW POWER MODULE
TIME TO ACQUIRE AFTER ATP	30 MOS.	34 MOS.	42-50 MOS.	48 MOS.
ORBITER DOWNTIME	3 MOS.	—	6 MOS.	3 MOS.
ADDED WEIGHT UP: DOWN:	7,840 4,380	2,100 2,100	9000 - 27000 (16,000 16,000)	30-45,000
LENGTH	7'	4' ABOVE TUNNEL OR PALLET	20'	30-40' ON DELIVERY FLIGHT
MISSION DURATION @ 21KW	14D	15-22D	INDEFINITE	INDEFINITE
TECHNICAL RISK	LOW	MODERATE	HIGH	MODERATE
MISSION FLEX. • INSTALLATION	ON PAD	ON PAD	OPF INSTALLATION ONE ORBIT LOCATION	ONE ORBIT LOCATION
• C.G.	FORWARD	MINIMAL	FORWARD - MINIMAL	NONE
DEFINITION NASA	200K 1.0MY	5YRS 4185K 42MY	—	5YRS 5.285K MSFC 179 JSC 8 MY
CONTRACTOR IRAD	175K RI	2100K MDAC 200K RI 1200K TRW 900 LMSC	1,500-3,000K RI	2000K MDAC 2000K TRW 600K LMSC
COST 1984 $ 1 UNIT	75-100$\overline{M}$	195$\overline{M}$	1115$\overline{M}$ (355$\overline{M}$ S/L)	1365$\overline{M}$ (355$\overline{M}$ S/L)

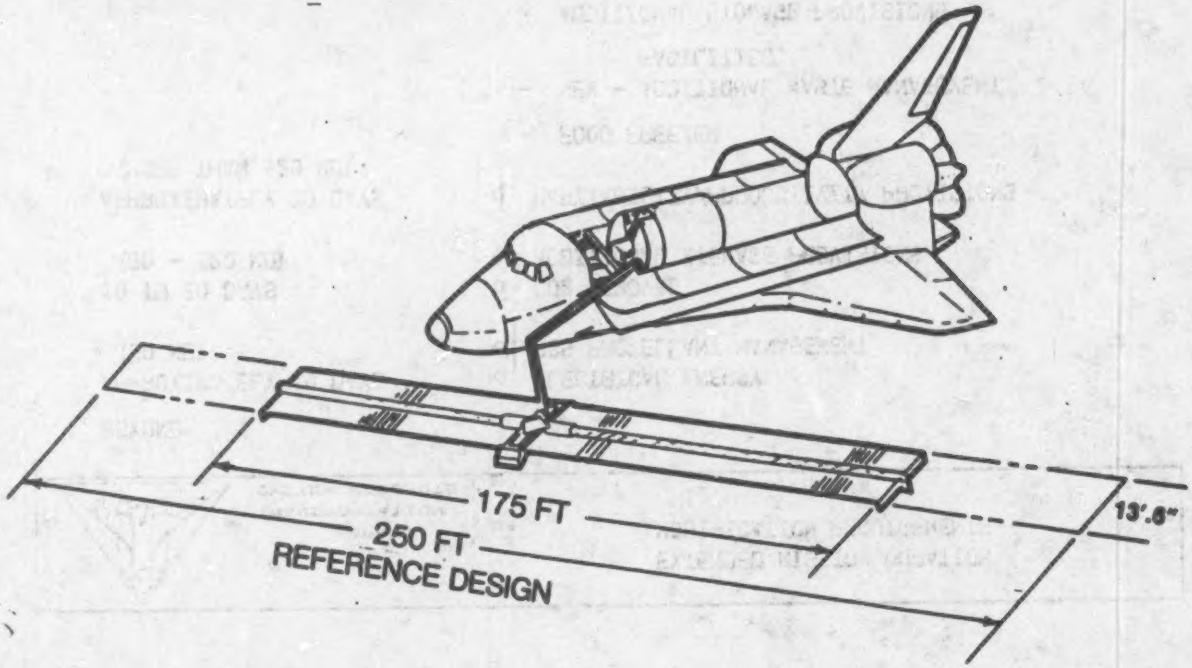
EXTENDED MISSION DURATION

BENEFITS

- INCREMENTAL
  - MORE UNITS OF DATA
  - OPERATIONAL CONTINGENCIES
    - WEATHER
    - EQUIPMENT
    - PROCEDURAL
- ENHANCING
  - ENABLING TO SOME MATERIALS PROCESSES, E.G., VAPOR AND SOLUTION CRYSTAL GROWTH
  - CYCLIC, E.G.,
    - REPEATED COVERAGE OF EARTH
    - SUN SPOT MOVEMENT OBSERVATION

POWER EXTENSION PACKAGE
NOMINAL CAPABILITY OPTION

TARGET WEIGHT: 1500 LB


13'.6"
175 FT
250 FT
REFERENCE DESIGN

SPACE
TRANSPORTATION
SYSTEM PROJECTS

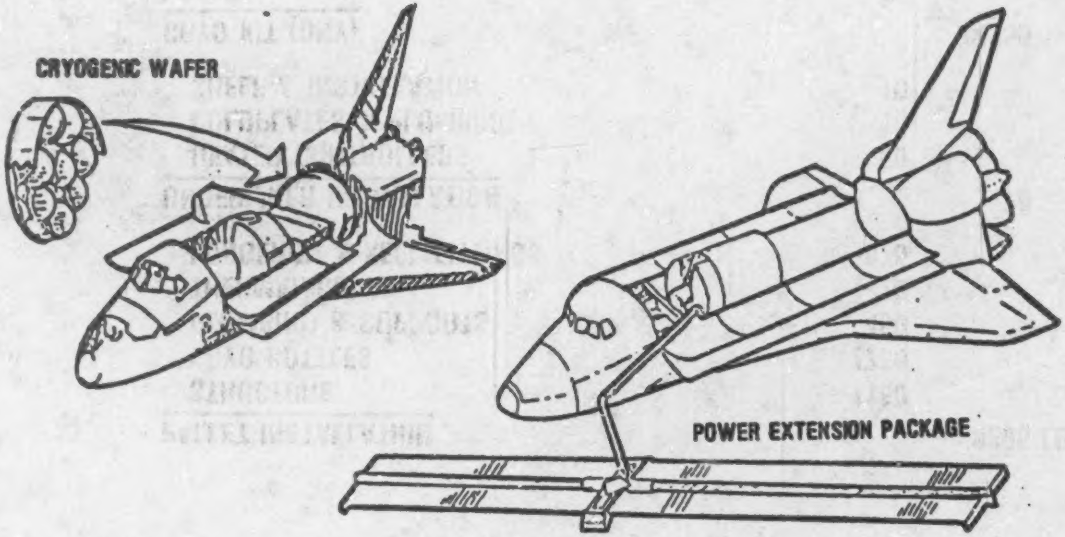
EXTENDED MISSION DURATION MODIFICATION REQUIREMENTS

BEYOND:

APPROXIMATELY 10 DAYS (60 MD)	o ELECTRICAL ENERGY o RCS PROPELLANT MANAGEMENT
10 TO 20 DAYS (60 - 120 MD)	o CO2 REMOVAL o ADDITIONAL STOWAGE PROVISIONS
APPROXIMATELY 30 DAYS (MORE THAN 120 MD)	o HABITABILITY/PRODUCTIVITY PROVISIONS - FOOD FREEZER - NEW - ADDITIONAL WASTE MANAGEMENT FACILITIES - ADDITIONAL STOWAGE PROVISIONS o VERNIER RCS REDUNDANCY o INCREASED LANDING WEIGHT REQUIRED

POTENTIAL GROWTH

10 - 20 DAYS

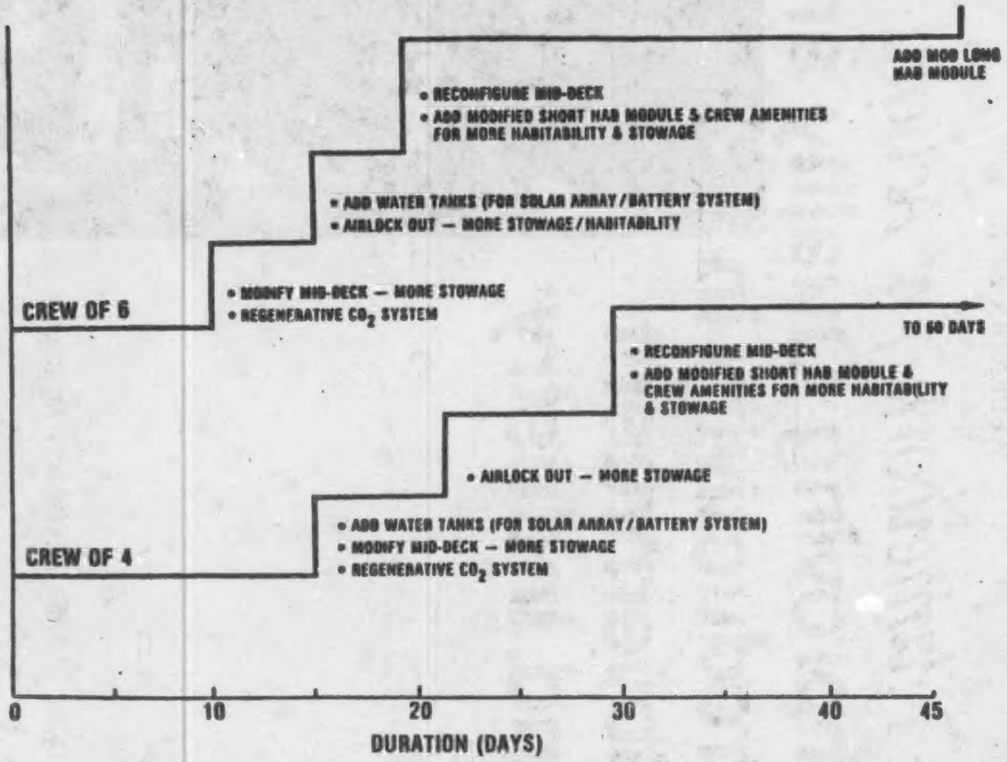

CRYOGENIC WAFER
POWER EXTENSION PACKAGE

Payload Bay Pallet Cryo Kit

Mass Properties

PALLET INSTALLATION		4285 LB
STRUCTURE	1160	
CRYO BOTTLES	1730	
PLUMBING & SUPPORTS	450	
THERMAL COVER	70	
LONGERON & KEEL FITTINGS	875	
UNDERLINER INSTALLATION		70
HEATER CONTROLLERS	50	
COLDPLATES & PLUMBING	10	
SHELF & INSTALLATION	10	
CRYO KIT (DRY)		4355
CRYO		3480
ORBITER SCAR		5
TOTAL CRYO KIT INSTALLATION		7840 LB

Orbiter Change Steps Are Straightforward



APPENDIX 20

A Framework for Action: Improving Quality and Productivity in Government and Industry

The Office of NASA Productivity Programs

December 1984

Report from NASA Symposium on Quality and Productivity

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Report from NASA Symposium on Quality and Productivity

Message from the NASA Administrator

To ensure that the National Aeronautics and Space Administration continues to be a highly productive and quality conscious agency, we have made it one of our highest goals to be a leader in the development and application of practices which contribute to high quality and productivity.

Technology represents America's greatest competitive strength. As a leader in research and development efforts for more than a quarter of a century, NASA has helped keep America on the cutting edge of technology. We need to build on this solid technology base and maintain our competitive position.

Management must direct its attention to strategies that enable us to develop world-class organizations. We must continue to increase productivity to improve our relative position in the world market and maintain our standard of living. Quality goals must become an integral part of all organizational activities. As President Reagan has said, "Following the example of our forebears, we need to rely on basics, yet dare to dream, always remembering that there is no substitute for quality."

I strongly endorse the recommendations contained in this report, both for NASA and as a framework for action to help individuals realize their greatest potential and for organizations to increase their effectiveness. It is my hope that you will read this report carefully and use those ideas and management concepts which are of value to your organization.

James M Beggs

James M. Beggs
December 1984

Foreword

On September 25-26, 1984, NASA sponsored the "Symposium on Quality and Productivity: Strategies to Improve Operations in Government and Industry." More than 650 top executives attended from more than 110 corporations, 35 government agencies, and 20 universities. The 36 speakers were high level leaders from some of the most successful organizations in the United States. The focus was largely on white collar quality and productivity. This report summarizes the general conclusions reached at the symposium.

An underlying conclusion of the symposium was that large, maturing organizations have a particular challenge to maintain high levels of quality and productivity, and guard against "hardening of the arteries." Without overt management action to continually renew and respark its drive, these organizations would eventually go out of business. Competitive pressures from abroad have crystallized these issues for many U.S. industries. For those who have not been directly challenged in the marketplace, the lessons learned are readily translatable into management imperatives. Although government organizations do not face that kind of competition, there is a distinct need to continuously rekindle their performance.

The report contains no "magic" formula for success or "quick fixes" for poor quality or low productivity growth. On the contrary, it stresses commitment to long-term strategies and a balancing with short-term bottom line results. It presents key underlying principles which, when implemented, can lead to continuous improvements in quality and performance. These principles should be viewed as techniques for regenerating an organization's vitality and, therefore, its prospects for continued success.

David Braunstein

David R. Braunstein
Director
NASA Productivity Programs
December 1984

Executive Summary

A new worldwide standard of quality has evolved and we cannot ignore its impact on our competitive position in the global marketplace. The challenge is to maintain our standing as a world economic leader. We must look at our management practices and determine what makes the difference between success or failure. This difference is often the way an organization brings out the great energies of its employees *and* sustains them from one generation to another.

The major findings of the symposium are organized into nine themes that build on this thought. Each encompasses a set of recommended actions and management practices that have been shown to contribute to high quality and productivity. Briefly stated, they are:

THEME 1:
Challenge for the Competitive Edge: Responding to Competitive Pressures.

The worldwide market competition we face as a nation and its impact on our organizations presents a serious threat. Eighty percent of our products are now challenged in the marketplace, compared to 20 percent ten years ago. A continuous quest for improvement, greater cooperation and trust, and a world-class standard needs to be built into organizational philosophies. All employees should understand the nature of the challenge. Management needs to convey the message and generate pressure for improvement.

THEME 2:
Make a Management Commitment to Quality and Productivity: Leading from the Top.

Quality and productivity are the responsibility of top management. Too often, however, they are assigned to staff with a "fix it if it goes wrong" mentality. As a result, they become buzz word goals rather than measurable objectives for which line managers are held accountable. Management involvement is meaningless unless demonstrated commitment is perceived by employees as genuine and long-range.

THEME 3:
Mesh Goals and Responsibilities: Opening Two-Way Communications.

A clearly articulated management philosophy can guide managers to speak and act honestly and confidently with customers and suppliers. To earn the support of all employees, management must communicate the goals and objectives of the organization. A clear, long-term management philosophy provides a sense of direction. On a broader level, government, industry and labor unions need to be less adversarial.

THEME 4:
Make Innovation Rewarding: Encouraging Innovation and Risk-Taking.

Maintaining the creativity and risk-taking attitude that make an organization successful is a major task of maturing organizations. It is well known that innovation is key to organizational survival in a fast changing economy. The true risk for any organization is to believe risk-taking is unnecessary for long-term survival. Management needs to recognize the proper place for innovation and risk-taking and create an environment that supports and rewards it.

THEME 5:
Build Dedication, Pride and Team Effort: Promoting Participative Management.

Successful organizations have a very high level of performance "over and above" that expected from its employees. Management needs to encourage and provide positive support for employee participation to maintain organization vigor. Middle management anxieties need to be addressed in this process, and mechanisms such as employee suggestion programs and quality circles should be used to sustain high levels of employee participation, so that employees feel committed and involved in the organization's success.

THEME 6:
Uncork Individual Talent: Controlling Bureaucracy.

As successful organizations mature, they tend to become preoccupied with controls and checks that are narrowly focused, parochial and inflexible. This process results in overregulation of activity, discourages initiative and slows down responsiveness to changing conditions. Management needs to thwart this tendency through decentralization and by providing freedom and protection for its innovators. Pushing responsibility to the lowest levels of an organization is the best way to make entrepreneurism a reality.

THEME 7:
Modernize for Survival: Encouraging New Technology.

Being a leader in research and development has been the key to keeping America competitive and in the forefront of technology. Although modernization involving new equipment and techniques is often difficult to justify on a return-on-investment criterion, management needs to have a philosophy that encourages new technology. Management also needs to have training plans for introducing new technology, to lessen the social impact on individuals.

THEME 8:
Maximize Human Capital: Developing Strategies to Improve Education and Training.

Basic to productivity is education and training; it defines and develops the quality of human resources for the future. We have fallen behind in educational achievements and in the number of engineers graduating on a per capita basis. Improvement in national productivity and competitiveness depends on new strategies for the training, education and social conditioning of our most important natural resources—our people.

THEME 9:
Improve Quality and Productivity Practices: Building a Quality Ethic.

High quality goes hand in hand with high productivity. In many organizations, total defect costs range from 15 to 40 percent of budgets. For maximum organizational effectiveness, continuous improvement goals are needed and must have total commitment by management. Every function has customer and quality objectives that have to be translated into specifics that are meaningful to each organizational effort. All levels of management must assess organizational activities and processes on the basis of their impact on quality and productivity—not just on bottom-line results.

Introduction

The United States has been the world leader in advanced technology for the last 50 years. Today, however, our economy faces stiff international competition. The dominant position we enjoyed in the world economy since World War II could only be temporary.

> "America's problem in recent years is that the climb to the top had been so easy we had come to take our economic leadership for granted. It was not hard to maintain leadership in world markets when there were few, if any, competitors." (James M. Beggs, NASA)

Ultimately, the relative position of the United States in the world economy will depend on the actions taken in individual organizations, by individual managers all across the nation. Thus, the audience for this report is that important group of leaders and managers in industry, government, education and labor who must work individually and collectively to meet the competitive challenge. Because of the large and growing white collar population in the work force (NASA's white collar costs are over 80 percent of its budget), we have concentrated on this area.

> "We must recognize that quality is not just for the factory. In the aerospace and defense industry, approximately two-thirds of our people and our costs are non-manufacturing related. We need to address quality in engineering, administration and other disciplines as well as within our factory operations. And, we must share what we've learned with our suppliers and sub-contractors, because their quality has an impact on our productivity, too." (R. J. Boyle, Honeywell, Inc.)

How do we respond to the challenge of international competition? We need to learn what we have done right and build on our successes. This requires that we analyze our strengths as well as our weaknesses.

Richard Foxen of Rockwell International Corporation states that our single strongest competitive element is the flexibility and adaptability of the American work force—both workers and managers. The quality of our human resources is high. Due to their social mobility and exposure to an advanced and widely accessible educational system, our people have a strong entrepreneurial spirit relative to other countries. Foxen further states that we have incomparable advantages over other nations in our pool of basic science, the depth and breadth of our industrial infrastructure and our flexibility for capital development. In addition, we possess the world's largest market with a common language, and our dollar has a central role in the international monetary system.

Despite these strengths, however, we have record trade deficits and American manufactured products no longer define the world standard for quality. We have lost dominance in many key industries, such as steel, autos, machine tools, and consumer electronics. Our investment in research and development as a percentage of the Gross National Product has waned, while in other major industrialized nations, it has increased. Our annual productivity growth rate lags behind that of Japan, West Germany and France. And as Robert Cole of the University of Michigan pointed out, this is not so much because the quality of U.S. products has declined—for the most part it has not—but that the quality of Japanese and German products has risen much more rapidly.

If this trend is allowed to continue, our nation will pay a heavy price in terms of lost jobs and decreased living standards. To respond to the challenges of foreign competition and to maintain American leadership in the world economy, we must focus on efforts that have long-term impact on quality and productivity. This requires reinforcing management practices that strengthen our long-term ability to be competitive. As Richard Kraft of Matsushita Industrial Company said:

> "Management thinking guided by this philosophy tends to focus on a continuous activity to improve the product and the process and to [illegible] the people rather than to focus on activity to achieve an improved P and L by accounting manipulation, tax adjustment activities, legal maneuvers, and other activities which can positively impact short-term results but add little substance to the basis for long-term success."

The following themes represent both a synopsis and synthesis of the issues discussed and the ideas, examples and recommendations offered at the NASA symposium. Each begins with a brief overview of the need for action, followed by a series of recommendations and illustrations on what organizations can and are doing to meet the challenge.

THEME 1.

Challenge for the Competitive Edge: Responding to Competitive Pressures

> "Being competitive today is a matter of what the whole society does: it is government, managers, employees, unions, educational institutions, consumers and taxpayers . . . all together, all part of the action." (Ruben Mettler, TRW, as quoted by Malcolm Stamper, The Boeing Company)

Whether they realize it or not, virtually all U.S. organizations are operating in a world economy. There is hardly a U.S. market that does not have at least 20 percent foreign penetration, and in some markets it runs as high as 80 percent. At the same time, our dependence on international markets is increasing. The message is clear: U.S. firms cannot continue to do business as they have in the past. Even high technology is not immune and must adapt, adjust and change in order to survive.

> "Surprisingly to many, in the last decade even our share of world exports of high technology products has declined from 25 to 20 percent. And the U.S. share of world trade in such services as insurance, finance, aviation, shipping and engineering also has declined from 25 to 20 percent." (Richard Foxen, Rockwell International Corporation)

Richard W. Foxen
Rockwell International Corporation

Recommendation 1.1 Recognize Foreign Quality/Productivity Gains

During the late '60s and early '70s the U.S. industrial base began to lose ground as Japan, West Germany and other industrialized nations cut into our industrial competitive edge. Robert Cole of the University of Michigan summarized the problem this way:

> "Suffice it to say that increasingly, our products have become less competitive worldwide and domestically when it comes to price, quality, and even product innovation."

Egils Milbergs, Executive Director of the President's Commission on Industrial Competitiveness, suggests that the U.S. public and private sectors "are beginning to define a uniquely American response to the competitive challenges we face."

Egils Milbergs
President's Commission on Industrial Competitiveness

> "Perhaps the most difficult, yet in some ways the most important, action is to take immediate steps to educate both our management and our work force regarding the significance of this globally interdependent environment." (Foxen)

Foxen points out that we need to understand:

- The U.S. share of world auto markets has declined from 32 to 21 percent, and from 19 to 10 percent for steel.
- In 1960, only 5 percent of our Gross National Product depended on foreign trade; today it is over 14 percent.
- Exports create a large demand for employment. Between 1977 and 1980, 30 percent of the increase in private sector employment was attributable to export growth.
- The more a company invests abroad, the greater its exports and employment at home.

These kinds of facts challenge many of the prevailing myths in our society regarding international trade and overseas investment. Before we can build a consensus for action among managers, labor unions and employees, we must examine these facts and develop a common understanding of the global challenge. Awareness precedes action. All employees must be made aware of the need to become a world-class competitor in order to survive. In addition, we must develop more effective management approaches to organizational activity even in those organizations which are not directly challenged.

William G. Ouchi
The University of California at Los Angeles

Recommendation 1.2 Use Consensus-Building in U.S. Societal Groups

When decisions are primarily reserved for "top" management, we tend to find large staffs, bottlenecks and stifled initiative. Based on organizational research, William Ouchi of UCLA has concluded that in the long run, the high performing type of company is the M-Form or multi-divisional organization. This organizational form addresses a major impediment to productivity—the ability to confront different points of view and reach a consensus on future directions at the lowest practical level. Consensus building encompasses cooperation, informal discussions and better coordination.

When the M-Form organization succeeds, it has achieved a balance between competition and teamwork. The organization is decentralized in the sense that each division operates as if it were a small entrepreneurial business, to encourage flexibility and creativity.

Ouchi argues that this principle can also be extrapolated to the national level and even to societies:

> "The basic building blocks are in place...the American Business Conference, the Conference Board, National Association of Manufacturers, Chamber of Commerce...They ought to be linked to one another..."

He points out that we need similar mechanisms in labor, municipalities and states, and civic and consumer groups. Mechanisms for consensus building will aid our ability to adapt to new economic realities.

Recommendation 1.3 Build Organizational Structures That Allow Change

Organizations must have the capacity to react to changing circumstances as they occur.

> "...in order to seize the competitive edge, we must maximize the flexibility and adaptability of American workers and managers." (Foxen)

Management must pay attention to practices and institutional conditions which impair responsiveness. These include antagonistic labor/management relations, short-term profit orientation, bureaucratic structures, and the lack of incentives and mechanisms for worker retraining.

> "We must create a stimulating, supportive environment in which our employees can become the sensors and masters of change rather than its victims." (R. J. Boyle, Honeywell, Inc.)

To make maximum use of our work force requires leadership and organizational attention to "basics." For instance, we need to:

- develop long-term rather than short-term scenarios for deploying capital and human resources;
- accommodate individual employee differences with respect to hours of work, career paths, and job design, etc.;
- create new ways to continuously upgrade employee skills;
- insist on management practices which foster customer interaction at all levels; and
- reinforce individual accountability for results.

To meet the competitive challenge we must have responsive organizations that can evoke the best efforts of all employees. As John R. Stepp, U.S. Department of Labor, observed:

> "In our present internationally competitive environment the increased productivity and the increased flexibility to respond to economic and business conditions which can result from labor-management cooperation may well make the difference between jobs or unemployment for many American workers."

John R. Stepp
U.S. Department of Labor

THEME 2.

Make a Management Commitment to Quality and Productivity: Leading from the Top

> "We at Sony believe that quality and productivity are the responsibility mainly of management." (Sadami Wada, Sony Corporation of America)

By virtue of position, top management develops the motivation and attitudes and thus the basic direction for an organization. Management leadership is also necessary to insure that the chosen strategies are translated into effective action. Long-term planning provides a consistent set of goals against which continuous improvements can be made. Leadership, however, should not be confused with authority:

> "Authority is position: leadership is style. One demands respect: the other earns it." (Malcolm Stamper, The Boeing Company)

Recommendation 2.1 Build a Top Management Philosophy Committed to Quality/Productivity

> "...lack of commitment from the top is the major impediment to getting a productivity program off the ground. If there is not action and demonstrated commitment from the president and/or CEO on down, forget it." (David Hamilton, Intel Corporation)

An organization is guided by its beliefs. These beliefs are the foundation upon which all policies and actions are based. One organization with such a credo is IBM. John Jackson of IBM discussed how Thomas Watson, Jr., stated that, to survive, an organization must have a sound set of beliefs, must adhere to these beliefs and:

> "...to meet the challenges of a changing world, it must be prepared to change everything about itself except those beliefs..."

Use every opportunity to show visible management support. The message should be delivered through all available media. Charles Joiner, Jr., of the Mead Corporation suggests using formal employee meetings, videotapes, company brochures, newsletters and individual meetings as well as normal contacts in the course of day-to-day business. The commitment must be sincere, long-term and not be compromised by short-term considerations or crises.

> "It is vital that top management make a true commitment to quality/productivity leadership...this commitment must be communicated to all employees, and reinforced through management actions and involvement. Make no mistake, employees can discern whether management is just paying lip service or is genuinely committed. If the Chief Executive Officer isn't commited, the employees won't be either." (John Manoogian, Ford Motor Co.)

Malcolm T. Stamper
The Boeing Company

Charles W. Joiner, Jr.
Mead Corporation

Lemmuel L. Hill
Naval Surface Weapons Center

Quality and productivity goals often become slogans that are not reinforced through management policies. This must be corrected, since a manager's example speaks louder than words. While the President or CEO may be the most visible champion, the key considerations of any management team are working together effectively and "modelling" to the rest of the organization the values and skills that are desired. As Charles Joiner stated:

> "The leader is the architect of that vision and above all else he or she must be for employees—the shining example of permanent human aspiration—inspiring employees to devote their powers to jobs worth doing."

He further stated:

> ". . . our team was built through sheer hard work. . . Our first meeting was tough and full of game playing. . . We simply needed to develop the trusting relationships found in mutual friendships. . . In the process we learned some new skills. . . Once the team was functioning it was then possible to begin moving. . . (it). . . down through the organization."

Recommendation 2.2 Make Management's Goals and Long-Term Plans Known Throughout the Organization

As Lemmuel L. Hill of the Naval Surface Weapons Center stated: "organizational effectiveness. . . is heavily dependent on. . . two attributes. . . dedicated, capable people, and a sense of purpose and direction." Transmitting the quality/productivity goals resulting from long-term planning to all employees is one of the most necessary kinds of communication, but at the same time one of the most difficult. In the words of Charles Joiner:

> "Once the future has been determined, it must be shared with all employees through an intensive communication process."

A clear and consistent view of the strategic direction of the organization must be communicated to all organization members. Organizations gain direction from a strategic vision and from the basic philosophies and values it embodies.

F. Blake Wallace
General Motors Corporation

The need to lengthen time horizons was a persistent theme at the symposium. F. Blake Wallace points out how the long-term view affects capital investment decisions at General Motors:

> "The solution which we at GM are using, and I believe that others in the industry are applying, is not to abandon the ROI analysis, but to supplement it with a clearer picture of our aspirations for five, ten or even fifteen years in the future and make appropriate factory modernization decisions to reflect those aspirations."

Long-term goals are important not only for capital investment, but for human resource development and product planning as well. This theme was echoed by Rockwell International's Richard Foxen, who said business leaders need to return to the basics of providing leadership in the development of both capital and human resources.

Recommendation 2.3 Develop Organizational Structures and Policies to Support Management Philosophy

Make sure that promotion policies, compensation policies, planning and budgeting systems, information systems, and other systemic mechanisms are in alignment with strategic direction and organizational philosophy. The behavior of managers and employees is shaped in part by management's example and in part by organizational structure and systems.

> "To create a trusting work environment, the manager's behavior must remain consistent with the stated beliefs in people." (Joiner)

Joiner uses management systems as a way of assuring that managers' actions are consistent with stated beliefs. These include the compensation program, selection process, performance reviews, educational opportunities, "speak-up" programs, and systematic approaches to planning and budgeting. Regular surveys are designed and carried out periodically to assess organizational health and insure that systems are aligned with the strategic vision.

Often the most powerful media are not those usually associated with communications. Harvey Weiss of Digital Equipment points out that communication in Japanese firms is enhanced by job rotation. Japanese managers and engineers rotate through many parts of the organization during their careers. They know the people and the operations, thereby facilitating communication and coordination. Weiss also warns that:

> "...we may mistakenly encourage people to stray from the 'desired mission' of the enterprise through the structure, the measurement system or the reward system we put in place."

Harvey L. Weiss
Digital Equipment Corporation

THEME 3.

Mesh Goals and Responsibilities: Opening Two-Way Communications

"In all organizations there are a number of prominent feelings or attitudes which the company stands for that influence how one should act in performing job assignments." (Fred A. Manske, Federal Express Corp.)

Communication in an organization is analogous to the nervous system of a human being: it provides the linkage between plans, behavior and actions. Thus, communication coordinates the joint actions of individuals, teams and departments. It is used to gain cooperation among different elements, to reward and recognize employees, and to convey information. In short, open two-way communications processes are essential to effective functioning.

Richard Kraft of Matsushita expresses well the relationship between organizational philosophy and communications:

> "My experience has convinced me that a clear management philosophy can allow managers to be confident in their business activities, and guide managers to speak and act honestly with both customers and employees."

Fred A. Manske, Jr.
Federal Express Corporation

Recommendation 3.1 Talk with Customers, Vendors and Contractors

Every level of your organization has "customers" and each should be attuned to these customer needs and desires. Lewis Lehr of the 3M Company describes how his company creates opportunities for both employee/customer interaction and vendor dialogue. These range from requiring officers of the company to spend one day a month selling the product, to user conferences involving face-to-face contact between designers and customers.

> "Imagine what would happen if the designers of, say, an office machine had to spend one day a month in the field, making service calls or listening to customer complaints. What would happen if the people responsible for drafting regulations in an agency had to spend one day a month helping people fill out the forms and meet the requirements?" (Lehr)

John Manoogian reinforces this point and adds a new dimension:

> "The customer is the final judge, so it is better to *determine needs from the customer's viewpoint*. . . The term 'customer' refers not only to the *external* purchasers of our products but also to our *internal* customers—the next person or organization in every stage of our business and manufacturing process."

John A. Manoogian
Ford Motor Company

If we are to improve quality and productivity, everyone, at every stage of the production process, must identify and listen to the customer. Encourage your vendors to communicate with you. Work closely with your vendors to identify and solve mutual problems. Establish mechanisms for regular interaction with your vendors. At Matsushita this takes the form of a mutually agreed upon quality improvement plan.

> "This plan usually includes a system for rapid and accurate feedback between the company and vendor so that problems on either side can be identified and acted upon, suggestions for improvement can be exchanged and progress can be tracked." (Kraft)

John A. Mittino
U.S. Department of Defense

Recommendation 3.2 Foster Government/Industry Cooperation for Mutual Benefit

More and more government agencies are reaching out to their contractors to enhance quality and productivity to the benefit of both. One notable example was related by Gerald Griffin of NASA's Johnson Space Center:

> "...in a series of workshops held last winter, we asked industry to give us their views on the major impediments to a more successful industry-NASA working relationship. And lo and behold, as a Walt Kelly comic strip character once put it so well: 'We have met the enemy, and they are us!' Our partners came back in short order and quickly pointed to a number of areas where we, NASA, presented stumbling blocks."

Such dialogue can lead to improved quality, shortened delivery schedules and reduced costs on government procurements. When coupled with incentive contracts, this can be a true win-win situation.

As an example of government's role in promoting this form of communication, John Mittino of the U.S. Department of Defense described steps being taken to encourage productivity-oriented capital investment by industry. This effort includes sharing productivity savings with subcontractors as well as prime contractors through the Industrial Modernization Incentives Program.

THEME 4.

Make Innovation Rewarding: Encouraging Innovation and Risk-Taking

> "...One essential step in renewing an organization is to set up a system for the care and feeding of innovators...a sponsor...proper awards...and the need to know what will happen to them if they fail..." (Lewis Lehr, 3M Company)

Organizations typically go through a life-cycle. When they are young, they are characterized by flexibility and innovation, and are usually staffed by a group of people with a strong drive for success. As they expand and mature, organizations tend to become specialized and segmented. Informal dialogue tends to be replaced by a preoccupation with formal policy and control. Instead of designing for success, Lehr points out, mature organizations tend to be more concerned with avoiding errors. "Playing it safe" becomes paramount. George Seegers of Citibank, N.A., describes the fate of Central Leather, once the nation's 24th largest company:

> "Central Leather failed to adopt new shoemaking techniques and equipment, and some time ago took its rightful place in the graveyard of companies that decided to 'play it safe!'"

Survival in today's economy depends on an organizational philosophy that nurtures risk-taking and innovation.

> "...companies that take risks generally prosper. The *true* risk for any company is to believe that risk-taking is unnecessary for long-term growth and survival." (Seegers)

Recommendation 4.1 Provide a Climate for Creativity

Lehr identifies three considerations in the care and feeding of innovators. First, they need a sponsor who can help obtain resources and shield the project if it falters. Second, innovators should be appropriately rewarded according to individual values. IBM's Corporate Fellows Program provides one example. Fellows are free to roam the company to select problems that interest them. The third consideration is the cost of failure. Innovators must be assured that failed projects will not cost them their jobs.

Harold Edmondson of Hewlett-Packard describes a supportive climate for innovation as one that allows people to be creative, challenges the person by providing progressively demanding creative experiences, provides direction for creative energy, provides measures for assessing success, and provides tangible rewards, e.g., status, resource support and peer awards.

> "Zealous volunteer champions. Innovators. Quite simply, they are *the key* to renewal in an organization. And we don't even need to look for them. They'll find us if we let them." (Lehr)

Lewis W. Lehr
3M Company

Harold E. Edmondson
Hewlett-Packard Company

John J. Franke, Jr.
U.S. Department of Agriculture

Recommendation 4.2 Recognize the Place for Risk-Taking

Innovation is not equally applicable or desirable in all parts of an organization. Furthermore, innovation is frequently accompanied by risk and additional costs. Management must therefore decide when these risks and costs are warranted by the potential gains. As Seegers points out:

> "The first lesson to be learned is that you must have a detailed, well thought-out template. . .for reaching your objective. The second is that you have to know when to follow the plan, and when to ignore parts of it. . .What every large organization—and especially the government—needs is periodic reviews of all activities, just to make sure that an obvious, somewhat risky, but better way of doing things is not being overlooked."

The timing of innovation is also important. Should the focus be at the early stage of a process, a later stage or should one strive for innovation throughout the process? The answer can be derived only from a well thought out business strategy which explicitly addresses the areas in which innovation in product or process is appropriate. John Franke of the U.S. Department of Agriculture had an interesting point of view on the benefits of some risk-taking.

> "Stirring the pot upsets and causes some disruption. But we feel the disruption is worth it. It provides the energy for new approaches and new methods."

THEME 5.

Build Dedication, Pride and Team Effort: Promoting Participative Management

> "The spirit of entrepreneurism may start at the top, but it is the middle levels where the attention to detail and commitment to quality make or break an entrepreneurial dream." (George Seegers, Citibank, N.A.)

Organizations that face strong competitive and budgetary challenges are forced to make full use of all resources. Although most organizations give lip-service to the slogan that people are their most important resource, management actions often tell a different story. Many employees are inhibited from making contributions to quality and productivity because they are not encouraged by management to participate in planning for improvements, problem solving, and other work-related decisions. Nevertheless, employees on the shop floor, in the office areas, and at various levels of management are extremely knowledgeable about their work and are aware of task-related problems.

Employees who are allowed to participate in decision-making have a commitment to make those decisions work. Participation gives an employee the opportunity to learn and master the environment as well as the chance to be recognized for making a contribution.

> "Forty-one thousand suggestions, 17 thousand adopted. $52 million saved. People just naturally become more productive when they are given something to live for, work for, and hope for." (Malcolm Stamper, The Boeing Company)

George E. Seegers
Citibank, North America

Recommendation 5.1 Make a Long-Term Commitment to Participative Management

> "The basic philosophy behind our way of doing things is to recognize that the employee on the job is often the best fitted to give advice about how to do that job... Just being involved in carrying out the tasks of a company without ever having a voice in the development of its policies or procedures is not sufficient participation." (John Felton, McCormick & Co.)

The journey toward a participative organization begins with a clear commitment to the philosophy of involving people as a "way of doing business." This commitment must start at the top, representing a long-term dedication which is conveyed in words and is in accord with the organizational structure and systems.

The Dana Corporation management explains its company philosophy, "The Dana Style," in a handout given to all employees:

> "The people of Dana, who are doing the job, know best how it should be done and they share the responsibility to decide what their job is, and to judge how well it is done." (Carl Hirsch, Dana Corporation)

John W. Felton
McCormick & Company, Inc.

Jack Sheinkman
Amalgamated Clothing & Textile Workers Union

In a unionized environment, the commitment to participation will necessarily involve the joint actions of management and labor and may be institutionalized through the collective bargaining process. In order to succeed, however, according to Jack Sheinkman of the Amalgamated Clothing and Textile Workers Union, union and management must view each other as equal partners in a long-term effort. He further notes that contractual agreements must include an explicit provision that the productivity improvement program will not lead to layoffs and will neither undermine nor supplant collective bargaining, but rather extend the process.

Recommendation 5.2 Build Supportive Management Structures and Policies

There is a wide range of employee involvement techniques: e.g., suggestion systems, quality circles, multiple-management, labor management committees and employee stock ownership plans. The particular form chosen to elicit employee participation does not appear to be as important as the fact that some structured process exists and that the process enjoys a broad base of support among those affected. Participative processes are implemented in accordance with the unique characteristics of each organization; there are no formulas or ready-made programs to guarantee success.

Mechanisms that encourage the flow of communication to upper management tend to increase commitment to the job and promote high levels of motivation.

> "More than anything else, quality or excellence stem from the people of an organization: their motivation, their drive, and most importantly, the way they relate to one another." (John Jackson, IBM)

John B. Jackson
IBM Corporation

Once the commitment has been made to move toward a more participative organization, a supportive management structure must be put into place. According to Charles Joiner, Mead Corporation, this may mean reducing the levels of management, broadening the span of control and reducing staff:

> "It is important to entrust a person with the job and then trust him/her to do it without unneeded bureaucratic red tape or management hierarchy."

In the early stages, participation alone may be enough to sustain a participative management style. In the long run, though, to sustain high levels of participation, organizations must make it clear to employees how the fruits of their participation are distributed.

> "Our stock purchase plan gets people to identify with Dana by making them owners of the company. Last year Dana people put out $17 million of their own money (along with $5 million in Dana's matching contributions) to buy 846,000 shares of stock." (Hirsch)

Other means of rewarding employees include bonuses, management recognition and enhancing status. Unfortunately, when organizations attempt to provide a more participative organizational climate, performance appraisal systems, promotion and compensation systems and other control systems may, unless modified, work in opposition to these goals. Management must periodically review these systems to ensure that they support participative management if this philosophy is to become institutionalized.

Recommendation 5.3 Address the Concerns of Middle Managers

Over the long run, no participative management process can be sustained without the involvement and support of middle managers. What is this "middle management problem"? Throughout this report, we have discussed the need to involve top management in launching any quality/productivity effort. As David Hamilton from Intel put it:

> "Senior management must set realistic goals for productivity improvement throughout. . . and be willing to hold middle management accountable for performance against these goals."

Gaining enthusiastic support among rank-and-file employees generally presents few problems. Unfortunately, the benefits to be derived from a productivity effort are not so readily apparent to middle management, for they tend to perceive themselves as being held accountable for a process over which they exercise little control. Moreover, middle managers may grumble that their role in the decision-making process has been usurped, at least until they become sufficiently involved in carving out a new role/relationship with employees.

One barrier to this support is lack of skill in operating in this "new" mode. McCormick and Company has solved this problem through a well-established program called multiple management. This involves giving middle managers a greater voice in running the business through the establishment of "junior" boards of directors.

> "The result at McCormick was small teams of employees meeting regularly on a voluntary basis to identify, to analyze, and to solve work-related problems—real company problems involving packaging, product development, productivity, cost reduction, distribution, sales, quality and inventory control." (Felton)

When introducing participative management processes, considerable effort should be devoted to identifying and confronting the fears and concerns of middle managers. For example, is it realistic to expect middle management support if top management does not allow middle managers to participate in decisions that affect them?

David J. Hamilton
Intel Corporation

THEME 6.
Uncork Individual Talent: Controlling Bureaucracy

> "Pushing responsibility to the farthest points of the organization is the best way to make entrepreneurism a reality." (Carl Hirsch, Dana Corporation)

Organizational barriers that inhibit entrepreneurism need to be broken. The true purpose of an organization is to support the individuals within it so they can be responsive to the organization's goals and be innovative and effective. Experience has shown that as successful organizations mature there is a tendency for bureaucratic symptoms to begin to erode the organization's effectiveness. Typically, it becomes preoccupied with controls and checks that are narrowly focused, parochial and inflexible. This maturation process, if unabated, leads to organizational decline as it loses the ability to adapt to the needs of the customers and meet the challenges of technology and the growth of competition.

> "In any organization, the inertia is on the side of those who play it safe. . . Bureaucracy begins when people are less concerned with being right than not being found wrong." (George Seegers, Citibank, N.A.)

Government laws, rules and regulations also have impeded the ability of organizations to remain flexible and adapt to change.

Carl H. Hirsch
Dana Corporation

Recommendation 6.1 Increase Employee Initiative Through Decentralization

F. Blake Wallace describes how GM is dealing with the bureaucracy issue:

> "Decentralization is what our new GM organization is all about. We've got to move faster in designing new products and bringing them to market. We've got to cut out bureaucracy, eliminate redundancy, and make more efficient use of our people. And probably most important of all, we've got to uncork individual talent. . .by giving our people the opportunity to take risks, assume responsibility. . .and earn rewards." (Wallace, quoting General Motors Chairman Roger Smith)

It is possible for management to thwart the bureaucratic symptoms of maturing organizations through decentralization and by providing greater freedom for the innovators. Managers must examine the given tasks and structure of an organization in such a way that the people who are supposed to make it work have the best chance to do so. The danger can be in placing people in various slots simply because it supports some form of an organization, whether it is effective or not. Often in bureaucracies performance at lower organizational levels is hampered by the need to check with multiple layers of management before a decision can be made. This stifles individual motivation, initiative and creativity. Arlene Triplett of the U.S. Office of Management and Budget describes a government field manager's frustration:

> "One of the problems with productivity in the government is that the poor guys out there in the field trying to deliver services to the taxpayers have to go through five and six layers of management before they get simple decisions like, 'Can I replace my secretary? Can I buy a file cabinet?'"

Arlene Triplett
Office of Management & Budget

Recommendation 6.2 Resist the Tendency to Overregulate and Provide Incentives for Productivity Improvement

> "For all the tools we have tried and texts we have studied, the real secret to improved productivity in our society is that simple but all elusive commodity, plain old fashioned *trust*—confidence in people and faith in their integrity." (Malcolm Stamper, The Boeing Company)

An example of overregulation in the Federal procurement process was discussed by John Mittino, who described the Department of Defense's efforts during the last three and a half years to improve productivity with its contractors. This effort began with 32 initiatives to shorten and simplify the acquisition process. At the present time priority is being given to six management areas which Mittino says provide the greatest challenge and the greatest potential payback. These areas include: program stability, multi-year procurement, economic production rates, realistic budgeting, support and readiness, and competition.

Gerald D. Griffin
NASA Lyndon B. Johnson Space Center

Another example of continuing DoD efforts to enhance contractor quality and productivity is through the use of contract incentives in its Industrial Modernization Incentives Program. NASA also is using the contractual process to encourage improved contractor performance.

> "Incentive contracts have always been our primary tool to motivate business in the R&D environment. We are now placing increasing reliance on this controversial tool to focus on developing even more innovative and cost-effective ways of doing business." (Gerald Griffin, Johnson Space Center)

Griffin further stated that 15-year contracts were planned to give contractors the opportunity to introduce long-range improvements. Later on, a fixed-price contract is envisioned to inject greater productivity and cost consciousness incentives. These new contracts will allow NASA to delegate extensive management responsibilities to the contractor as NASA reduces its day-to-day involvement in operations support.

In his review of initiatives undertaken by the President's Commission on Industrial Competitiveness, Executive Director Egils Milbergs outlined some components of a recently passed bill which will "modify the antitrust laws to permit precompetitive R&D ventures." A central goal is to reduce paperwork and costs for industry and government.

THEME 7.

Modernize for Survival: Encouraging New Technology

> "Effects of technology are not instantaneous, but there is a competitive imperative to use the most productive technology available...most of foreign competition strength is application of the newest technology." (Fred Garry, General Electric Co.)

New technology is making inroads on all fronts—office automation, new manufacturing equipment and innovative processes. New products appear daily and one company's new product becomes part of the next company's new process.

Office automation, the technology with the greatest impact on white collar productivity, has taken hold in the United States at a much faster pace than factory automation. In general, the equipment costs less, it can be introduced piecemeal, and most important, the fundamental technologies are already available. Any organization with a desire to automate office procedures can find a reasonable selection of affordable equipment on the market. Experience has indicated sizable savings. F. Giannantonio, Avon Products, noted a positive return on investment in just one year.

> "We measured indirect savings on productivity gains of 23 percent for management/professional staff and 53 percent for our secretarial/administrative staff."

But new technology means more than a way to do something faster or cheaper. It means social change and changes in the way work is organized and managed. Obtaining the full benefits of technology requires cooperation.

> "Once the employees, their unions, and our management team joined hands, that new technology really began to pay off." (Garry)

Recommendation 7.1 Plan for the Technical and Social Impact of Technology

Careful planning is necessary to insure that the potential benefits of new technology are realized. These plans must not only address changes in work methods and procedures, but also in how work is organized and managed, and how employees who operate and maintain equipment will be affected.

In older plants, according to Garry, successful introduction of new technology requires open, honest, two-way communication between management and employees and a commitment to retraining. In G.E.'s experience, many low-skilled workers have been successfully trained to handle high-technology jobs, thereby minimizing worker dislocation.

Frederick W. Garry
General Electric Company

Frank Giannantonio
Avon Products, Inc.

William G. Pfeiffer
ITT Telecommunications

In white collar organizations, information technology will dramatically alter patterns of social interaction and access to information. This will lead to power shifts in the organization that could have profound consequences if not anticipated. William Pfeiffer of ITT discussed the "electronic cottage" concept, an extreme case of decentralization. Stimulated by the increased power and portability of computers, people will be able to work in their homes or other locations physically separated from the central organization. Widespread application of this concept will not only alter work practices but will create major organizational and even societal changes.

> "Clearly, we're in for some profound changes, in both technology and office life. . . We must rethink our procedures and organizations." (Pfeiffer)

Recommendation 7.2 Stimulate Modernization Through Government Support and Incentives

Government has played an important role in the technology introduction process and should continue to do so. John Mittino described DoD's manufacturing technology program aimed at introducing new technology into the production environment. He stressed the importance of current DoD initiatives designed to share dollar savings resulting from a defense contractor's productivity-oriented capital investment, through efforts such as its Industrial Modernization Incentives Program.

The impact of such programs can be seen in success stories like that of General Dynamics, manufacturer of the F-16 fighter. Willie Livingston of General Dynamics cited technology-based productivity improvements that have reduced the number of man-hours required to build an F-16 from 110,000 in 1979 to less than 30,000 in 1983. Overall, the F-16 program, stimulated by government incentives, will produce savings to DoD in excess of $1 billion.

Willie C. Livingston
General Dynamics

Robert Walquist of TRW, Inc. gave another example of government/industry cooperation. He described the joint efforts of NASA and TRW to make the Gamma Ray Observatory spacecraft program a model for more productive ways of doing business. The program has already implemented a series of productivity macro-goals to lead company, sub-contractor and individual employee productivity increases. TRW's efforts cover both team building and the use of new technology. With the use of mini computers they have developed a common government-contractor database which has reduced the need for reporting. Through video conferencing they have increased communications and reduced travel costs.

Robert L. Walquist
TRW Inc.

Recommendation 7.3 Maximize Computer-Related Technology

White collar operations in industry and government are benefitting from computer/communications technologies. In aerospace firms such as Lockheed Missiles and Space Company, computer-aided design and manufacturing (CAD/CAM) are increasingly viewed as a means of reducing the labor content of products and improving product quality. In the future, these technologies will provide a way to cope with a projected shortage of skilled engineers and technicians. Lockheed's Fred Oder reported productivity savings from CAD ranging from 36 to 73 percent when compared to the cost of manual design.

While advances in office automation are occurring daily, the major office productivity breakthroughs have not yet occurred. Major gains await improved component compatibility and the convergence of computer and telecommunications technologies. William Pfeiffer of ITT points to three main concerns and needs of users that must be satisfied if office automation is to fulfill its promise. First, there is a need for easily understandable software triggered by English language commands. Second, the user needs an integrated package of hardware, software and communications technology. And finally, the most difficult need to satisfy is the standardization of system architecture. Knowledgeable managers can influence hardware and system vendors by communicating these requirements. Until these needs are met, the office automation contribution to quality and productivity improvements will continue to be less than optimum.

> "The office of the future has not yet arrived…the technologies necessary to create it have been around for about ten years…What's missing is the "glue"—the systems architecture that allows equipment from different vendors to work together…In other words, we have an electronic Tower of Babel." (Pfeiffer)

Frederic C. E. Oder
Lockheed Missiles & Space Company, Inc.

THEME 8.

Maximize Human Capital: Developing Strategies to Improve Education and Training

> "Human capital is our most valuable national resource. It is insufficient to try to discuss productivity without discussing education which defines and develops the quality of human resources for the future." (Owen B. Butler, Proctor & Gamble)

Improvement in national productivity and competitiveness depends on the training, education, and social conditioning of our most important national resource—our people. Over the past several years business and government leaders have noted a decline in the basic preparation of our young people to meet the diverse challenges and complexities of our fast-changing society. Blame is commonly put on the public school system, but family, school, the community, government and industry must all share responsibility.

According to Butler, industry spends approximately $30 billion annually on remedial and continuing education to make up for educational deficiencies in its work force. Schools, from the primary grades through college, must consider how to adapt their curricula, not just to the ever-changing job market, but equally important, to an ever-changing society. In this effort, the family, community, government, and industry, each have roles and responsibilities in guiding schools and motivating and educating young people for more productive lives. Each group must bear the responsibility and give it high priority.

Owen B. Butler
The Procter & Gamble Company

Recommendation 8.1 Inform Educators of Required Job Skills

In the past, new employees entering the work force generally worked at low skill tasks on narrowly defined jobs that were relatively easy to learn. Today, employees are required to perform a broad range of tasks. They are expected to operate and maintain equipment, perform administrative tasks, participate in goal-setting and budgeting, and work in groups and teams that are self-directed and guided by principles rather than detailed procedures. Even people with strong educational backgrounds require a large amount of training to perform in this situation.

However, employees who lack a strong foundation in literacy, numbers skills and, above all, the ability to learn, require even more training. Industry should bear the responsibility for specific job training, but our educational system must provide students with the basic skills required for employability in today's business environment.

Recommendation 8.2 Encourage Increases in the Number of New Scientists and Engineers

Industry should work closely with colleges to insure that scientists and engineers receive broad training and provide incentives that will attract them to manufacturing careers. The United States is falling behind in the number of new scientists and engineers compared with our competition.

> "In 1982, engineering and science accounted for only 20 percent of all bachelors degrees earned in the United States. This compares with 25 percent of all such degrees earned in Japan; 34 percent in West Germany and more than 50 percent in the Soviet Union." (James M. Beggs, NASA)

Robert E. Cole
University of Michigan

Robert Cole of the University of Michigan notes that we not only have fewer technical people, but we deploy them in ways that may be adverse to our overall economic competitiveness.

> "...Many of our most talented researchers and engineers have been siphoned off into the defense and aerospace industries. ...As I visit Japanese companies, I am struck by just how many engineers they have to throw at fairly mundane technical problems... Japanese technical personnel working directly in the consumer products industries have been able to generate improvement after improvement, resulting in reduced costs, higher quality and productivity."

Cole also points out that the training and career progression of engineers and technical support personnel in Japan give them a competitive edge. In particular, our nation is weak in the area of technical support people. In Japan, high school graduates are given extensive in-house technical training, allowing them to assume many engineering tasks. This frees up graduate engineers to work on more complex tasks. Our nation's weakness reflects the weak technical background of high school graduates and inadequate training and career path planning in industry. As a result, we are not developing and retaining individuals with the required competencies as well as we should.

Recommendation 8.3 Continue Training Employees for New Technology

Changes in process technology are occurring at an accelerated pace as industries attempt to remain competitive. This means that employees must continually learn new skills in order to keep pace. As one example, Butler observed that the only thing in its disposable diaper line that hasn't changed in the past 20 years is the name of the product! Manufacturing technology has changed and computers have replaced electrical relays for process control. In another area, employees who used to stack paper towel products now program a robot that performs the stacking. Office employees are experiencing changes in technology that are almost as dramatic.

An organization that values its work force and seeks to maintain stable employment must devote considerable time and effort to training.

> "To keep pace with these changing work place demands we must invest 7-10 percent of employees' time in training. That's an investment of up to $3,000 per year per employee in wage dollars alone. Clearly, when we invest that kind of money, we want to make sure that we get a proper return. We have to have employees who have the ability to learn and use their training." (Butler)

THEME 9.

Improve Quality/Productivity Practices: Building a Quality Ethic

> "The whole measure of our success...will boil down to quality performance. Shoddy workmanship, defective materials, inadequate quality control, cash overruns—all can be improved or eliminated." (James M. Beggs, NASA)

For industry, the stakes in building a quality ethic are customer satisfaction, cost competitiveness, and ultimately, survival. At IBM no level of defect is acceptable. John Jackson of IBM states: "More than anything else, quality or excellence stems from the people of an organization...and quality is everyone's job...Our total quality costs are roughly 15 to 40 percent of the revenue stream." For government, the penalties for failed quality are cost overruns and missed supplier milestones. A quality ethic should permeate every aspect of an organization, starting with hiring the best people and then challenging them to top performance.

> "In contrast to just the traditional emphasis on profits, costs, and production goals, leadership has to become obsessed with making sure all decisions are driven by quality improvement, customer satisfaction and building an innovative team environment." (David Braunstein, NASA)

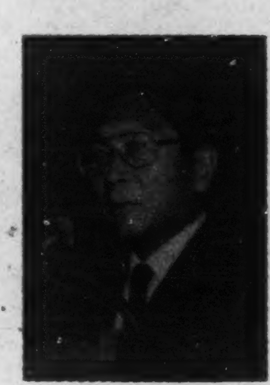
In these comments from his welcoming address to symposium attendees, David Braunstein, Director of NASA Productivity Programs, stressed the underlying mandate to instill the quality ethic in any organization. As such, the pursuit of quality and productivity is more an attitude, and not a program goal per se.

Recommendation 9.1 Make Quality a Total Management, Employee and Supplier Commitment

As top management sets organizational goals so the quality ethic is driven by these goals. Leadership must transcend the narrow perspective of quality in technical terms to one which perceives quality as tantamount to organizational survival. Management must translate quality goals from the abstract, slogan level and relate them to all aspects of employee performance. Quality and productivity are consistently described as different sides of the same coin. This means that employees have to see their jobs not only in terms of "getting the product out" but also in terms of meeting top quality goals. Within an organization this involves how organizational elements cooperate and satisfy each other. Outside the organization it involves the relationship and dealings between customers and suppliers.

> "Our managers, supervisors and foremen are thoroughly educated in the policy that quality is the very life of Sony products...They are trained in the field to understand how important quality is for sales and after-sales service." (Sadami Wada, Sony Corporation)

James M. Beggs
NASA



Sadami Wada
Sony Corporation of America

Cooperation between a company and its vendors and suppliers is viewed as a major contributing factor to the high quality levels attained by Japanese manufacturers. Instead of responding to peremptory demands for higher quality, Japanese vendors establish mutually agreed-on targets for improvement as part of a quality plan. This features rapid, two-way feedback for generating suggestions, problem identification and solution and structuring a system for tracking progress.

The importance of this relationship is the basis of current DoD initiatives described by John Mittino. Since quality has become such a significant issue in the acquisition process, DoD, as the customer, is reemphasizing policies and programs aimed at promoting improved quality practices by contractors.

> "The Department (DoD) encourages commitment from top management and is promoting increased awareness and attention to quality problems during design and manufacturing. DoD is also re-examining its qualification and certification programs to determine whether quality is sufficiently stressed. Perhaps most importantly, we are trying to find new ways to include quality history in our source selection process." (Mittino)

Recommendation 9.2 Incorporate Quality Goals into All Organizational Activities

Quality goals must be understood in terms of the work that an organization performs, the process by which the work is performed and the management system under which the organization is run. As Richard Boyle of Honeywell has stated:

> "When we talk about quality, we're not just talking about products. We're talking about three elements that must be present...quality of work, quality of work life and quality of management."

Richard J. Boyle
Honeywell, Inc.

Specific goals must be established for all three elements. Quality of work is what most people mean when they speak of quality. Does the product or service meet the requirements? Is it satisfactory to the customer? This analysis involves all individuals and functions of the organization.

Quality of work life is the degree to which the work environment allows and motivates employees to contribute to the success of the organization. Does the environment offer challenge, responsibility and appropriate rewards? Boyle observes that:

> "Quality of management is the key to sustained quality improvement. It involves fostering leadership that has the technical and intellectual skills to set the course for the organization."

The successful translation of quality goals into an organization's activities begins when employees can answer the question, "What is *my* job?" The job should be defined in terms of both the goods or services produced and the needs of the "customers" who receive them. When employees can answer this question, the organization can then focus on quality goals to increase its effectiveness. Without quality goals and a plan for achieving them in all organizational activities, we cannot develop a process for continual improvement.

> "The more effective approach has been to establish a quality improvement plan. . . The plan usually involves a system for rapid and accurate feedback. . . (so that) suggestions for improvement can be exchanged and progress can be tracked." (Richard Kraft, Matsushita)

Recommendation 9.3 Assess Organizational Activities and Processes As Well As Bottom Line Results

People and processes provide the conditions for quality improvement, which is the driver for productivity. As viewed by Carl Hirsch of Dana Corporation:

> "The pursuit of quality is never finished, because the capacity of our people to produce quality is virtually unlimited. That's why we at Dana will not stop evolving and striving. . . . It may be good—but excellence is never really enough."

Management must continually strive to improve the quality of its products, as well as the capabilities of its processes. Responsibility rests with all levels of management to review these processes and determine, through analysis, what they contribute to the bottom line. These reviews must be conducted at key points and be based on facts. Moreover, these reviews should focus on defect prevention.

> "Screening by rejection only increases cost. Therefore, efforts must be made to manufacture right the first time. This is the real quality control. You must be able to obtain the desired level of quality with the least waste." (Wada)

Richard Kraft recommends following the Japanese example of accepting the quality teachings of Dr. W. Edwards Deming, Dr. J. M. Juran and others. The Japanese have accepted the premise that superior quality leads to competitive success, costs little and creates a worldwide demand for goods because of their reputation.

Richard A. Kraft
Matsushita Industrial Company

APPENDIX A

Symposium Program and Speakers

Tuesday / 25 September 1984

8:00 AM Registration

9:00 AM Opening Remarks
David R. Braunstein, *General Chairman and Director, NASA Productivity Programs*

9:20 AM Welcome
James M. Beggs, *Administrator, NASA*

9:45 AM Break

10:15 AM "Committing to Excellence"
James M. Beggs, *Administrator, NASA*

11:00 AM "Management Philosophies Associated with Leading a Successful Organization"
Malcolm T. Stamper, *President, The Boeing Company*

11:45 AM Room Assignments and Afternoon Activities
A. Lawrence Guess, *Chairman, AIAA Coordinating Group and*
Director, Commitment to Excellence,
Martin-Marietta, Baltimore Aerospace Division

12:00 NOON Luncheon

Presentation by the crew, Shuttle Mission 41-D
(First flight of the Orbiter *Discovery*)

Introduction
Gerald D. Griffin, *Director, NASA Lyndon B. Johnson Space Center*

1:30 PM ***Session A / Challenges and Problems***

Session Co-Managers		AIAA Coordinator
C. Robert Nysmith	**Richard L. Engwall**	**George J. Vila**
Associate Administrator for Management *NASA*	*Manager* *Systems Planning, Analysis Assurance* *Westinghouse Electric Corporation*	*Consultant* *General Dynamics Corporation*

41-D NASA Shuttle Flight Crew
(left to right) Michael L. Coats, Steven A. Hawley, Richard A. Mullane, Judith A. Resnik, Charles D. Walker & Henry A. Hartsfield

***Session A / Challenges and Problems** continued*

► **Workshop A1: International Competition**

Chairman	Coordinator
D. Bruce Merrifield	**Ronald H. Schack**
Assistant Secretary for Productivity, Technology and Innovation	*Vice President*
U.S. Department of Commerce	*Business Development*
	Martin Marietta, Baltimore Aerospace Division

"Understanding Changes in the U.S. Competitive Position: International Competitiveness"
Robert E. Cole, *Professor, Center for Japanese Studies, University of Michigan*

"Challenges Facing U.S. Industry"
Richard W. Foxen, *Senior Vice President, Strategic Management and International*
Rockwell International Corporation

"Quality and Cost Competitiveness"
John A. Manoogian, *Executive Director, Product Assurance*
Ford North American Automotive Operations

1:30 PM

► **Workshop A2: Organizational Attitudes and Orientation**

Chairman	Coordinator
Laurence J. Adams	**Z. Henry Hyman**
President and Chief Operating Officer	*Director*
Martin Marietta Corporation	*Engineering Business Management*
	General Dynamics Corporation

"Some Informal Remarks on the M-Form Society"
William G. Ouchi, *Professor, Graduate School of Management*
The University of California at Los Angeles

► **Workshop A3: Management Practices**

Chairman	Coordinator
Ralph C. Bledsoe	**Anthony J. LoPaso**
Special Assistant to the President	*Director of Programs—A18*
The White House	*Sperry Gyroscope, Sperry Corporation*

"Why Wrestle with Jellyfish?"
Richard J. Boyle, *Vice President and Group Executive*
Defense and Marine Systems Group, Honeywell, Inc.

"Japanese Management in U.S."
Richard A. Kraft, *President and Chief Executive Officer, Matsushita Industrial Company*

"Are Incentives Right for U.S. White Collar Organizations?"
F. Blake Wallace, *General Manager, Allison Gas Turbine Division*
General Motors Corporation

3:00 PM Break

3:20 PM ***Session B / Techniques for Improvement***

Session Co-Managers
Richard A. Stimson
Director
Industrial Productivity
Office of the Under Secretary of Defense for Research and Engineering
U.S. Department of Defense

Edward G. Siebert
Director of Corporate Productivity
Grumman Aerospace Corporation

AIAA Coordinator
Peter W. Wood
Senior Vice President
Booz, Allen & Hamilton Inc.

► **Workshop B1: New Trends in Management**

Chairman
Alan M. Lovelace
Vice President
Productivity and Quality Assurance
General Dynamics Corporation

Coordinator
David Westerman
James Forrestal Memorial Industry Chair
Defense Systems Management College

"Quality in Practice at IBM"
John B. Jackson, *IBM Vice President, Quality, IBM Corporation*

"Applying Productivity Principles to New R&D Programs, NASA/TRW GRO Project"
Robert L. Walquist, *Vice President and General Manager, Space and Technology Group TRW Inc.*

"Productivity Improvement in the Acquisition Environment"
John A. Mittino, *Assistant Deputy Under Secretary of Defense-Production Support U.S. Department of Defense*

3:20 PM

► **Workshop B2: Use of Technology**

Chairman
Donald R. Beall
President and Chief Operating Officer
Rockwell International Corporation

Coordinator
Harold K. McCard
Vice President and General Manager
Avco Systems Division

"New Technology Implications on the Work Force"
Frederick W. Garry, *Vice President, Corporate Engineering and Manufacturing General Electric Company*

"Modernization in Aerospace"
Willie C. Livingston, *Director of Productivity and Automated Office Systems General Dynamics Fort Worth Division*

"The Road from Babel: Prospects for Integrated Office Systems"
William G. Pfeiffer, *Director of Management Systems, ITT Telecommunications*

► **Workshop B3: Education and Training**

Chairman
Dan Quayle
U.S. Senate (R-Indiana)

Coordinator
Edward U. Clark
Program Manager
Electro-Mechanical Division
Northrop Corporation

"A Corporate Perspective of the Adequacy of Human Capital"
Owen B. Butler, *Chairman, The Procter & Gamble Company and Vice Chairman, Board of Trustees Committee for Economic Development*

5:00 PM Reception

Wednesday / 26 September 1984

8:30 AM Welcome
David R. Braunstein, *General Chairman*

8:35 AM Opening Remarks
John L. McLucas, *President, American Institute of Aeronautics and Astronautics*

8:45 AM "Renewing Large Organizations"
Lewis W. Lehr, *Chairman and Chief Executive Officer, 3M Company*

9:30 AM Break

9:50 AM ***Session C / Renewing Large Organizations***

Session Co-Managers
Brian Usilaner
Associate Director
National Productivity Group
General Accounting Office

Robert L. Vaughn
Director of Productivity
Lockheed Missiles and Space Company, Inc.

AIAA Coordinator
Joel M. Graybeal
Aerospace Engineer
ANSER

► **Workshop C1: Organizational Approaches**

Chairman
George F. Mechlin
Vice President
Research and Development
Westinghouse Electric Corporation

Coordinator
Bartley P. Osborne, Jr.
Chief Advanced Design Engineer
Lockheed-California Company

"Counteracting the Stifling Effects of a Large Organization"
Harvey L. Weiss, *Vice President, Mid-Atlantic & South States Area Management Center Digital Equipment Corporation*

"Building Teams and Maintaining Trust"
Lemmuel L. Hill, *Technical Director, Naval Surface Weapons Center*

"Balancing Risk Taking and Encouraging Entrepreneurism"
George E. Seegers, *Vice President, Public Issues, Citibank, North America*

"Making the 'Z' Concept Work"
Charles W. Joiner, Jr., *President, Mead Imaging Division, Mead Corporation*

► **Workshop C2: Encouraging Innovation**

Chairman
L. William Seidman
Dean
College of Business
Arizona State University

Coordinator
Richard R. Brown
Head of Applied Physics
Boeing Aerospace Company

"Encouraging and Maintaining an Innovative Work Climate"
Harold E. Edmondson, *Vice President, Manufacturing, Hewlett-Packard Company*

► **Workshop C3: National Initiatives**

Chairman
Robert L. Fairman
Assistant Secretary for Administration
U.S. Department of Transportation

Coordinator
William T. Mikolowsky
Director of Business Development
Lockheed-Georgia Company

Wednesday / 26 September 1984

"Preview of the President's Commission on Industrial Competitiveness"
Egils Milbergs, *Executive Director, President's Commission on Industrial Competitiveness*

"Labor-Management Cooperative Programs"
John R. Stepp, *Acting Associate Deputy Under Secretary*
Bureau of Labor-Management Relations and Cooperative Programs
U.S. Department of Labor

"Hurdles Stifling the Federal Manager's Ability to Improve Productivity"
Arlene Triplett, *Associate Director for Management, Office of Management and Budget*

"Productivity Initiatives at USDA"
John J. Franke, Jr., *Assistant Secretary for Administration*
U.S. Department of Agriculture

11:50 AM Luncheon

Address
Joseph P. Wright, *Deputy Director, Office of Management and Budget*

2:00 PM ***Session D / Success Stories***

Session Co-Managers
States L. Clawson
Director
Commerce Productivity Center
U.S. Department of Commerce

Arthur L. Welch
Director
Product Assurance
Martin Marietta Aerospace
Michoud Division

AIAA Coordinator
Dirk H. Lueders
Colonel, U.S. Army
(Retired)

► **Workshop D1: Employee Involvement**

Chairman
Roy A. Anderson
Chairman and Chief Executive Officer
Lockheed Corporation

Coordinator
George A. Schlanert
Director, System Integration and Laboratories
Douglas Aircraft Company

"Step Back into the Future: The History of Multiple Management"
John W. Felton, *Vice President, Corporate Communications*
McCormick & Company, Inc.

"Union and Management Joining Forces"
Jack Sheinkman, *Secretary-Treasurer, Amalgamated Clothing and Textile Workers Union*

"Sony Keeps High Quality and Productivity in the United States"
Sadami (Chris) Wada, *Vice President and Assistant to the Chairman*
Sony Corporation of America

► **Workshop D2: Management Involvement**

Chairman
John Carroll
Executive Vice President
Communications Workers of America
AFL-CIO

Coordinator
James A. McAnally
Vice President
Defense Systems
Martin Marietta Denver Aerospace

"Keeping the Bureaucracy in Check"
David J. Hamilton, *Senior Productivity Analyst, Intel Corporation*

"The Dana Style: Participation Builds the Climate for Productivity"
Carl H. Hirsch, *Vice President, Corporate Planning, Dana Corporation*

"Contractor and Government: Teamwork and Commitment"
Gerald D. Griffin, *Director, NASA Lyndon B. Johnson Space Center*

► **Workshop D3: New Technology Applications**

Chairman
Richard D. DeLauer
Under Secretary for Research and Engineering
U.S. Department of Defense

Coordinator
Martin N. Titland
Vice President, Space Products
Fairchild Space and Electronics Company

"Paperless Office at Work"
Frank Giannantonio, *Director, Information Services, Avon Products, Inc.*

"CADCAM Productivity"
Frederic C. E. Oder, *Executive Vice President, Lockheed Missiles & Space Company, Inc.*

"Getting Organizations to Accept New Ideas/Technology: The Federal Express Experience"
Fred A. Manske, Jr., *Senior Vice President, Ground Operations and Sales*
Federal Express Corporation

4:00 PM ***Program Synthesis Panel***

Moderator
A. Lawrence Guess, *Chairman, AIAA Coordinating Committee and*
Director, Commitment to Excellence, Martin Marietta
Baltimore Aerospace Division

Session A
C. Robert Nysmith, *Associate Administrator for Management, NASA*

Richard L. Engwall, *Manager, Systems Planning, Analysis, and Assurance*
Westinghouse Electric Corporation

Session B
Richard A. Stimson, *Director, Industrial Productivity, OUSDR&E*
U.S. Department of Defense

Edward G. Siebert, *Director of Corporate Productivity, Grumman Aerospace Corporation*

Session C
Brian Usilaner, *Associate Director, National Productivity Group*
General Accounting Office

Robert L. Vaughn, *Director of Productivity, Lockheed Missiles and Space Company, Inc.*

Session D
States L. Clawson, *Director, Commerce Productivity Center*
U.S. Department of Commerce

Arthur L. Welch, *Director, Product Assurance, Martin Marietta Aerospace*
Michoud Division

5:00 PM Adjournment

APPENDIX B

Acknowledgments

The papers and presentations of the symposium speakers, listed in Appendix A, were used as the basis for writing the report. Many individuals from government, industry and the academic community contributed much of their time to writing, re-writing and improving the content and organization of this document.

Special thanks and much appreciation go to the following: Thomas C. Tuttle who served as Project Facilitator and Cecilia Jordan who prepared numerous drafts, Maryland Center for Productivity and Quality of Working Life; American Institute of Aeronautics and Astronautics; Arthur R. Barzelay, Grumman Aerospace; Richard L. Engwall, Westinghouse Electric; Joel M. Graybeal, ANSER; A. Lawrence Guess, Martin Marietta; Edward G. Siebert, Grumman Aerospace; Robert L. Vaughn, Lockheed Missile & Space; George J. Vila, General Dynamics; Arthur L. Welch, Martin Marietta; and Peter W. Wood, Booz, Allen & Hamilton. The following individuals in the Washington area were of special assistance: States L. Clawson, Department of Commerce; Charles E. Fritts, General Accounting Office; and Carl W. Zerambo, Booz, Allen & Hamilton. The staff of the NASA Office of Productivity Programs made valuable contributions to the final preparation of the report: Lynwood P. Randolph who served as Project Coordinator; Polly Newton; Marcia Nickols; Jessie Harris; Gene Guerny and Linda Vinson.

David R. Braunstein

APPENDIX 21

NASA

National Aeronautics and
Space Administration

SPACE STATION MANAGEMENT PLAN AND PROCUREMENT STRATEGY

Prepared By:

OFFICE OF SPACE STATION
NASA Headquarters
Washington, D.C. 20546

DECEMBER 14, 1984

PREFACE

The logical next step in the exploration and development of space is an orbiting space station. United States leadership in this effort was ensured on January 25, 1984, when President Reagan, in his State of the Union Message, announced a national commitment to develop a permanently manned space station, to do so within a decade, to invite other nations to participate, and to promote private-sector investment in space. The National Aeronautics and Space Administration (NASA), as the responsible federal agency, has initiated the Space Station Program in accord with the President's directive and the funding authorized and appropriated by Congress.

The Space Station will be the centerpiece around which a major segment of the U.S. civil space program of the future will be structured. It will be an orbiting laboratory, test assembly and service center, manufacturing site, and observation platform that will open broad new arenas of opportunity for the scientific, commercial, federal, and international users of space. Its contributions to mankind's knowledge and well-being will range from new methods of producing rare substances to a vastly increased understanding of deep space and the origins of the universe. The Space Station will provide the foundation for free world leadership in space for the 1990's and beyond.

Congress has supported the principle of developing a Space Station and has provided NASA with resources to define a program. In response to the President and Congress, NASA is broadening its horizons to ensure that other federal agencies, the private sector, and this nation's friends and allies have an opportunity to participate in the program. Congress and NASA share the view that space is a resource with great potential for commercial development. To exploit the potential that a Space Station can provide, NASA is identifying and will adopt the most appropriate techniques for management and control of the overall program.

This document responds to a request from the Science and Technology Committee of the House of Representatives for the "NASA Space Station development management plan and procurement strategies." Although major elements of the plan already were decided or were in preparation, completion of this document should, as the Committee stated, enable both NASA and the Committee better to "focus on management issues which may need further attention at the outset of the space station development program."

In preparing this management plan, NASA first established a number of principal guidelines. The first and most important of these is that the Space Station must be developed and operated in a way that responds to the needs of its users. NASA has, at the outset, provided for significant involvement of potential Space Station constituents in planning, organization, and management of the program. The Space Station must be flexible enough to accommodate users not yet identified. It must reflect concern for both costs of the operation of the Space Station itself and costs to the individual users. Furthermore, the Agency must maintain the vitality of its entire program, particularly in space sciences and applications, as the Space Station is being designed, built, and operated.

The second major guideline is that NASA should draw heavily on its past experience in program management. This experience led NASA to plan an extensive program definition, now under way, which will result in an early and thorough technical, cost, and schedule understanding prior to development. NASA has adopted a three-tiered structure that places responsibility for overall program direction in Headquarters, day-to-day technical and resources management in a separate office at the Johnson Space Center, and development of major portions of the Space Station at Goddard Space Flight Center, Lewis Research Center, Johnson Space Center and Marshall Space Flight Center. Additionally, NASA concluded, after a thorough examination of options, that it should manage the systems engineering and integration of the program elements, but that the program must be managed in a way that would minimize restructuring of the Agency.

This document describes the alternatives that were considered as these and other guidelines were expanded and reflected in the plan for Space Station management. Although the plan will carry on through the definition phase and into the design, development, and acquisition phase of the initial Space Station elements, it should be viewed as a "living" document that will change as the program undergoes organizational and management adjustments. For instance, the extent of international participation in the program will not be known until foreign financial commitments are made late in the definition phase; once agreed to, the participation of international partners will require modification of some details of the management plan. Changes in the physical configuration of the Space Station could require adjustments in program management. It should also be noted that this document does not describe the NASA internal institutional processes and activities at Headquarters and the Centers which support all of the Agency's programs including the Space Station.

The plan presented in this document reflects a thorough consideration of Program options and objectives, and provides a suitable framework within which the program can evolve consistent with the direction of the President and the intent of Congress.

Philip E. Culbertson
Associate Administrator
Office of Space Station

SPACE STATION MANAGEMENT PLAN AND PROCUREMENT STRATEGY

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1.0 INTRODUCTION

1.1 PURPOSE OF PLAN

The purpose of this plan is to describe the management system and procurement strategy for development of a permanently manned Space Station within a decade in accordance with the President's directive, issued in the State of the Union Message on January 25, 1984. This plan defines the management structure and identifies the separate and combined responsibilities of all participants engaged in the Space Station Program, including other U.S. government agencies, industry, and universities, as well as international participants. The main options considered in evolving the overall management plan are discussed along with the rationale for the selected approach. This plan also describes the intra-NASA relationships, controls, and safeguards which ensure that the Space Station Program will be managed with clear lines of authority, and well-defined responsibilities and accountabilities.

1.2 PROGRAM GOALS AND OBJECTIVES

The Space Station Program goals, as established by the President, are threefold:

(1) To develop a permanently manned Space Station within a decade;

(2) To invite other countries to participate so we can strengthen peace, build prosperity, and expand freedom for all who share our goals; and

(3) To help promote private sector investment in space through enhanced U.S. space-based operational capabilities.

In support of these goals, the following long-term Space Station Program (SSP) objectives have been established by NASA:

- Establish the means for a permanent and productive presence of people in space;
- Provide space-based facilities that enable routine, continuous utilization of space for science, applications, technology development, commercial exploitation, and space operations;
- Develop and exploit the synergism of the man-machine combination in space;
- Provide system elements and operational practices for an integrated national space capability;
- Reduce the cost and complexity of working and living in space while also assuring a high level of safety and reliability;
- Stimulate the mutual benefits traditionally derived from cooperation in space with allies and friends;

- Ensure leadership in space for the United States in the decade of the 1990's and beyond;
- Develop Space Station elements that are compatible with and can interface with operational Space Transportation System (STS) hardware; and
- Provide a focal point for motivation and educational leadership of future scientists and technologists.

1.3 BACKGROUND

The President's January 1984 directive represented the next step in a broad-based U.S. civil space program to develop space flight capabilities and to exploit space for scientific, technological, and commercial purposes. Over the past several years, a strong background of technical opinion, congressional support, and public consensus about national policy has emerged in support of NASA's development of a permanently manned space station.

The President's National Space Policy statement of July 4, 1982, emphasized the goal of establishing a "more permanent presence in space," in such a way that it will be possible for friends and allies around the world to participate in taking this major step. The SSP is implementing the clear direction of the President's policy.

NASA Administrator James M. Beggs, in May 1982, authorized the establishment of the Space Station Task Force, which initiated a focused effort toward conceptual definition of a Space Station Program. The Task Force undertook a two-year, Agencywide study of the SSP from a technical, managerial, contractual, and institutional standpoint. The Senior Interagency Group for Space also examined the question of developing a Space Station and recommended going forward with such a program.

NASA's repeated examinations of -- and studies aimed at articulating -- national space goals and priorities determined that a key prerequisite for the required space infrastructure was a versatile and reliable method of space transportation. The civil space program has achieved this goal with the recent maturing of the Space Transportation System. Today, regular shuttle flights are conducted from the Kennedy Space Center in Florida, where the fleet of four Shuttle Orbitors are launched and now are able to land as well. Long-anticipated space missions are being accomplished involving research, satellite launches and on-orbit repairs, and spacecraft retrieval and return to Earth. Every new flight attests to the dependability of the system and the skill of the astronaut flight crews. To support missions requiring high inclination (polar) orbits, a new launch site, funded by the U.S. Air Force, is nearing completion at Vandenberg Air Force Base in California.

With the capability of the shuttle, it is now realistically possible to establish the "more permanent presence in space" referenced in the President's statement -- one that enables people to work in space full-time in the interest of scientific, commercial, and technological advancement and for the greater benefit of all mankind.

1.4 THE SPACE STATION TASK FORCE

The Space Station Task Force charter was to provide focus and direction for all Space Station planning activities and to identify mission requirements for the overall program. In addition, the Task Force was to establish a sound technical foundation for Space Station definition and to develop a preliminary program plan.

In order to concentrate on the planning work that had to be accomplished during the formative stages of the program, four phases of program development were defined: Mission Requirements and Concept Definition, Phase A (1982-1984); Definition and Preliminary Design, Phase B (1984-1986); Design and Development, Phase C/D (1987-1992); and the Operational and Evolutionary Phase (1992 and beyond). The cost, schedule, and technical plans resulting from Phase B will enable NASA to proceed into the Design and Development Phase, Phase C/D, with a high degree of confidence.

Identification of mission requirements was accomplished through a series of activities that included the science community, other government agencies, potential international partners, and U.S. aerospace contractors. Eight Phase A mission-analysis study contracts were awarded to major U.S. aerospace firms. Also, a number of foreign governments conducted, at their own expense, parallel mission analysis studies. The results of the U.S. and foreign studies were informally exchanged.

Parallel to the contracted activities, NASA initiated a series of management and procurement planning and technical analysis studies within the NASA field centers. These in-house analyses and studies were focused through various Space Station Task Force Working Groups - Program Planning Working Group (PPWG), Operations Working Group (OWG), and Mission Requirements Working Group (MRWG) - formed in the summer of 1982. The PPWG conducted the management and procurement options studies that resulted in the selection of the management approach and the procurement approach and a strawman Request for Proposal (RFP) for the definition phase studies. A Concept Development Group, formed in the spring of 1983, led the systems engineering and integration effort to develop Space Station concepts, architecture, and system requirements. This was accomplished by using the products from the MRWG and OWG as a set of baseline mission and operations requirements.

The Space Station Task Force integrated and assimilated the results of the extensive internal and contractor studies and analyses into a Program Description Document that defines the Task Force recommendations in the areas of mission requirements, system requirements, and program planning. This six-volume document, called "Yellow Books," dated March 1984, served as a primary input for the RFP for the Space Station definition phase (Phase B). It also provided the basis for the program content as currently defined. The Task Force was replaced by an Interim Space Station Program Office and then by the Office of Space Station, which was established on August 1, 1984.

The assignment of lead center responsibilities (Level B) for Space Station was made to the Johnson Space Center in April, 1984 and a team was established with approximately 200 people from the NASA field centers, Headquarters, and the Jet Propulsion Laboratory (JPL), and led by the newly appointed Level B

Program Manager and Deputy. The purposes of this team were to prepare an RFP for the definition phase, define a Space Station reference configuration concept, and prepare a planning base for the management of this phase of the program. This Management Plan contains the results of those planning activities.

1.5 PROGRAM CONTENT

The requirements to be satisfied by the initially deployed Space Station will be a function of the needs of Space Station users, constrained as necessary by the funding limitations placed on the Program. However, the concept of the initial Program is to provide a manned base, two unmanned platforms, and the acquisition of a previously developed Orbital Maneuvering Vehicle (OMV). An improved OMV automation robotic capability will be developed by the Space Station Program. A schematic representation of the Reference Configuration Station is presented in Figure 1-1.

1.6 PROGRAM SCHEDULE

NASA has planned an extensive definition effort with sufficient resources to ensure that when hardware development is initiated, the program will be thoroughly defined, responsive to user requirements, and based on the proper mix of man and machine, and will incorporate the most advanced technology available. Definition efforts will include an automation plan to utilize the best of both manned and man-tended modes to achieve optimum productivity at the Station. The Space Station schedule for the initial definition and development activity is shown in Figure 1-2. The major milestones that follow the contract start dates (CSD) are defined as:

Interface Requirements Review (IRR): The seven-month period during which Level B and the Level C Work Package (WP) centers and their contractors perform studies to define the overall Space Station Program, which is intended to culminate in a set of baseline interface requirements. These baseline requirements will be the basis for the preliminary design tasks to follow during the later phase of the definition effort. At IRR, the major system interface requirements will have been established and refinements in the WP definition and interfaces will have occurred.

System Requirements Review (SRR): During the two-month period between IRR and SRR, the baseline system requirements will be formalized by Level B and the initial WP interfaces will be documented. At SRR, the contractors will review the requirements applicable to their WP to be used during the preliminary design phase and NASA will approve the baseline system requirements.

System Design Review (SDR): SDR is the final definition and preliminary design review. At this point, a total Space Station Program preliminary design with all the necessary cost and schedule estimates and management plans will be complete and Phase C/D can commence.

Preliminary Design Review (PDR): During Phase C/D, a preliminary review of the final design documentation is held approximately one year after contract start.

Critical Design Review (CDR): During Phase C/D, a critical review is held when the design documentation is nearly complete.

FIGURE 1-1

INITIAL MANNED SPACE STATION REFERENCE CONFIGURATION

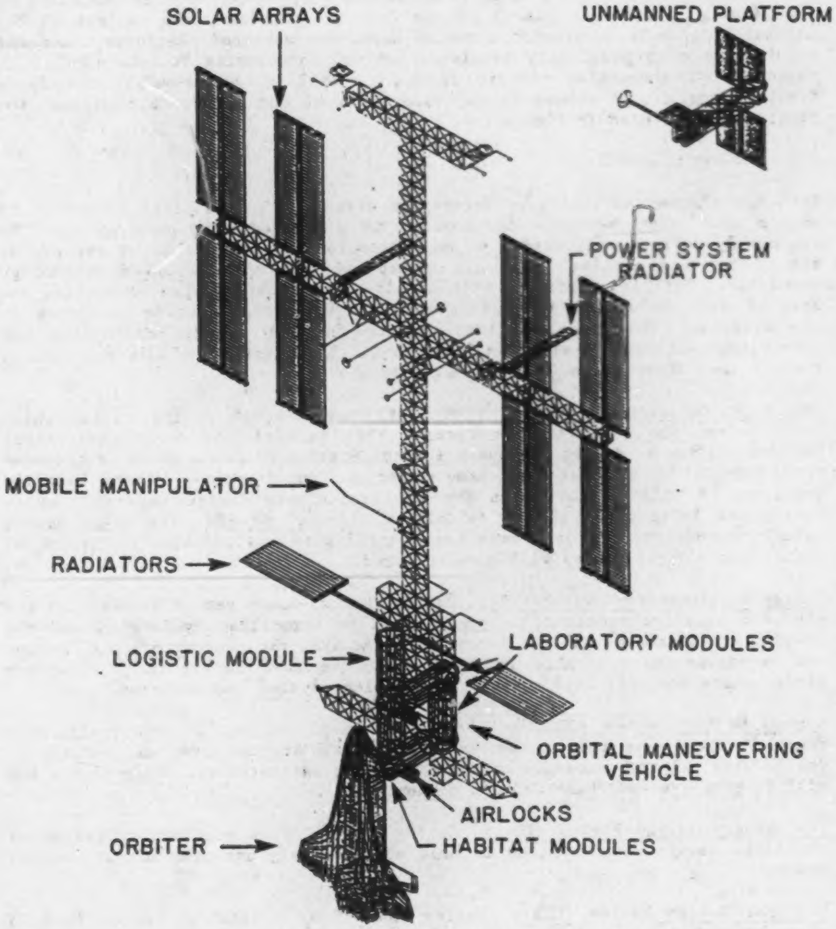
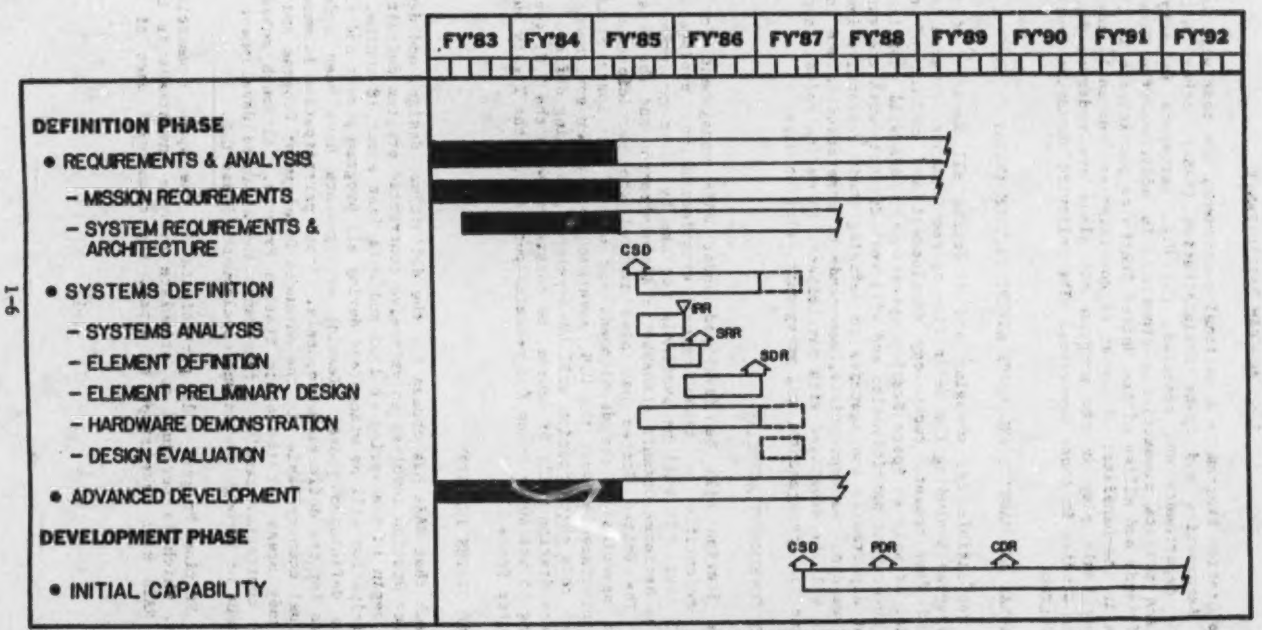

SOLAR ARRAYS
UNMANNED PLATFORM
POWER SYSTEM RADIATOR
MOBILE MANIPULATOR
RADIATORS
LABORATORY MODULES
LOGISTIC MODULE
ORBITAL MANEUVERING VEHICLE
AIRLOCKS
ORBITER
HABITAT MODULES

FIGURE 1-2

SPACE STATION PROGRAM SCHEDULE



CSD – CONTRACT START DATE
CDR – CRITICAL DESIGN REVIEW
IRR – INTERFACE REQUIREMENTS REVIEW
PDR – PRELIMINARY DESIGN REVIEW

SDR – SYSTEM DESIGN REVIEW
SRR – SYSTEM REQUIREMENTS REVIEW
⌂ – LEVEL A CONTROLLED MILESTONE

12/14/84

2.0 PROGRAM PARTICIPANTS

The Space Station Program is a national commitment, one that will involve the National Aeronautics and Space Administration (NASA), other United States government departments and agencies, the U.S. aerospace industry, universities, and private commercial customers. In addition, the President has invited friends and allies of the United States to participate in the program and share in its benefits. A number of countries are currently examining the roles they could play in the program and plans are underway for parallel definition studies in those countries. The following summarizes participation in the program.

2.1 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

NASA is responsible for managing and directing all aspects of the Space Station Program including the definition of requirements, Program definition, design and development, technology development and control of technology information as well as Space Station operations. NASA will coordinate international government participation and will work directly with the various U.S. government departments and agencies in defining their respective involvements and requirements. As appropriate, memoranda of understanding and interagency agreements will be developed with participants to define roles, responsibilities, financial arrangements, and management relationships.

2.2 OTHER GOVERNMENT AGENCIES

The Space Station will be developed under NASA management for missions involving scientific or technological experimentation, applications, and commercial uses. It will be available for use by other government agencies such as the National Oceanic Atmospheric Administration and the Department of Defense. The United States has also invited the participation of other government agencies in the development and use of the Space Station. The detailed interfaces between the U.S. government and other government agencies under which this participation will be developed are being defined. All uses of the Space Station will, of course, be consistent with the U.S. government's undertaking to use outer space for peaceful purposes in the Treaty on Peaceful Uses of Outer Space.

2.3 UNITED STATES INDUSTRY

The approach that NASA has chosen for the definition, design, and development of the Space Station involves an extensive contracted program definition phase that will begin in the spring of 1985 and will last about 18 months. Industrial participation will be widespread during all program phases and especially during the definition phase. Teaming arrangements have been made by the contractors for the definition proposals. Broad participation is expected, on an individual company basis, in the Advanced Development Program and in other special study areas for the Space Station Program. Although somewhat narrowed, the contractor teaming arrangements and advanced development projects will continue on through design and development, Phase C/D.

The Space Station Program will participate in the space commercialization initiative, which is designed to stimulate private investment in the space program. NASA will take steps to expand the commercial uses of space by inviting private companies to partake in manufacturing, processing, and other ventures on board the Space Station that take advantage of the space environment.

2.4 UNIVERSITY RESEARCH

In addition to the longer-term role as users of the Space Station for scientific and technical research and experimentation, university researchers are fulfilling several key roles in the Program that will have a more immediate impact. Because the Space Station will, as one of its principal tasks, support scientific research and technological development in space, NASA is making a concerted effort to develop a Space Station that is optimally designed for its intended users. The academic community is participating in the Task Force on Scientific Uses of the Space Station, a committee under the Space and Earth Science Advisory Committee. Under the chairmanship of Stanford University's Professor P.M. Banks, the Committee is developing detailed science requirements for the Space Station. Requirements from the scientific and academic communities have also been solicited from the several other advisory committees and councils now assisting NASA.

Another key function of the academic community is its involvement in the Advanced Development Program. A number of key technologies relevant to Space Station design are being supported by the Program beginning in FY 1985. A portion of this Advanced Development effort is expected to be accomplished by university researchers. NASA's Space Station planning is also benefitting from assistance provided by academia in certain selected study areas such as automation and robotics, human productivity, and data system design.

2.5 INTERNATIONAL PARTICIPATION

A basic goal of U.S. national space policy is the encouragement of international cooperative activities in the national interest. A major Space Station Program planning guideline has been to develop the potential for international participation in the Space Station Program. When President Reagan directed NASA to develop a permanently manned Space Station, he also invited the nation's international friends to join us in the program and to share the benefits. Substantial international interest surfaced during NASA's preliminary Space Station planning activities. Parallel mission requirements studies were conducted by Canada, the European Space Agency (ESA), France, West Germany, Italy, the United Kingdom, and Japan and the results have been shared with NASA. These foreign entities are now studying potential participation in the definition and development phases of the Program and refining user requirements. Consistent with NASA guidelines on international cooperation, funding for cooperative activities will be provided by other governments or specific participants. Management mechanisms for international participation in the Space Station are currently being developed.

3.0 MANAGEMENT AND TECHNICAL APPROACH

3.1 DEVELOPMENT OF THE MANAGEMENT STRATEGY

The National Aeronautics and Space Administration (NASA) recognized at the outset that the program it was undertaking would represent a major management challenge. Indeed, the principal non-engineering concern of the Space Station Task Force leadership through 1982 and 1983 was the formulation of a Space Station Program concept that would best serve national, institutional, and programmatic goals and objectives. Major factors considered in developing the Program management concept were: (1) distributed program architecture that took maximum advantage of the wide base of NASA's organization capabilities; (2) an extended program definition process that, in keeping with the recommendations of the 1981 study of NASA project management (the Hearth Committee Report) that reviewed both manned and unmanned programs, would thoroughly explore the risks, and analyze the technical, schedule, and cost options before commitments were made for hardware development; (3) a long-life capability that met the goal of a permanently manned presence in space by the early 1990's; and (4) system capabilities that could be enlarged or improved technologically with time after the initial station became functional. The overriding importance of a "user-friendly" Space Station was recognized early on and has been a basic principle in the development of the management approach.

The basic assumption that directly bounded the size and weight of the Space Station elements was that the Space Transportation System (STS) would be used to place the Space Station elements into orbit. Simply stated, the STS Orbiter cargo-carrying capability established the upper limits on Space Station module size and weight. Consequently, a generic concept for the Space Station architecture emerged very early during the existence of the Space Station Task Force. The Space Station modules would be specially outfitted for such functions as laboratories, crew habitats, and logistic supply units and there would be two or more unmanned platforms.

The acceptance of the modular approach to the basic architecture immediately generated the major questions of how to assign the project management responsibilities for hardware development within the Agency, and how to assure, at acceptable cost, the continuity of excellence in system engineering and accuracy of Space Station program memory over the decades - long operation and evolution envisioned by NASA. The option of assigning the entire responsibility for hardware development management to a single NASA center with system engineering included as a prime system contractor's responsibility was considered. This option was rejected because the possibility of having to depend on a single prime contractor's system engineering organization over a period as long as fifteen or twenty years appeared to have a major disadvantage for NASA. The obvious alternative perhaps is to do the system engineering "in-house," and divide the total development task into smaller, more manageable packages that can be assigned for project management to the various NASA centers.

The Task Force then addressed the question of how many, or few, packages there should be for best management of the technical effort. The number of development packages (now known as "work packages") that was considered ranged from two to eight. This range was considered separately by both NASA and aerospace industry sources and scored on the basis of four criteria: work package integrity, common hardware potential, interface simplicity, and evolutionary potential. This examination of options involved weighting factors for subsystem complexity based on estimated cost.

This process, although not conclusive, suggested strongly that the best approach would be to have four separate work packages for hardware development, with a lead organization to be responsible for the program management and system engineering and integration (SE&I) of the separate efforts.

Thus, the question of contracted versus in-house SE&I had to be examined critically by NASA. Would an in-house approach truly serve the best interests of the Space Station Program? Would it tend to sustain the vigor in the NASA civil service engineering capability? Finally, could SE&I be done in-house? The answer to all of these questions was "yes," realizing that it would be possible to establish some specialized engineering support by contract should it become necessary.

Where the lead organization for program management should be located was decided on the basis of available skills and experience. NASA decided not to perform this function at NASA Headquarters as this was viewed as counter to the management principal of maximum delegation, and because the quantity and type of engineers needed were only available at the NASA centers. The consensus was that the Lyndon B. Johnson Space Center (JSC) was the location most suitable for creation of a program management organization to perform the important SE&I function because of the proven experience of the JSC personnel during the Apollo and Space Shuttle programs.

Next, NASA had to decide on the specific content and center assignments for each work package. The modular architecture concept for the base Space Station was a principal driver in the establishment of definition phase work packages, along with a critical assessment of the system and component design and development experiences of the various NASA centers during earlier major space flight programs - Apollo, Skylab, Space Transportation System (Shuttle), Landsat, Space Telescope, and Voyager. The subsystem and technology capabilities of the centers also were evaluated as was the probable impact of assignments on center resources. The Skylab, Shuttle, and large structural vehicle and propulsion engineering experience at the George C. Marshall Space Flight Center (MSFC) clearly suggested a work package that would cover a common module with related subsystems, propulsion systems for Space Station, and the environmental control and life support system which performs control and distribution of fluids and gases in quantity throughout the Station.

The experience and expertise of the Johnson Space Center in managing previous manned space flight programs and the Space Transportation System of the Johnson Space Center were key factors in the establishment of its responsibilities. These include definition of manned capability elements (extravehicular activity systems, habitat module, airlocks, and manipulators), the main structures, STS interfaces, and essential interfaces with on-orbit mission operations.

The definition of platforms, free flyers and the definition of requirements for the outfitting of laboratory modules as well as the analysis of satellite servicing functions was a logical grouping of Space Station Program functions that was entirely consistent with the many years of scientific and applications payload and spacecraft development experience of the Goddard Space Flight Center. The recent success of the Solar Maximum Satellite repair mission which was conceived and planned by the Goddard Space Flight Center underscored the validity of the assignment of satellite and platform servicing analyses.

The initial analyses of total electric power requirements for the Space Station and for the on-board experiments identified a major subsystem design challenge. New technologies of solar energy conversion may be needed. Because the Lewis Research Center had been involved in the technology for large-capacity solar energy conversion for a number of years, it was decided to place the responsibilities for the electric power system definition in a separate work package.

A key management problem that required early resolution was how the Space Station Advanced Development Program would be planned and executed. The Program strategy is to advance selected technologies during the first few years to broaden the range of subsystem options that will be available and to reduce technical risks. The Office of Aeronautics and Space Technology and the Space Station Program are jointly funding and managing advanced development projects to reduce the technical risks across the Program.

A major focus during 1983 and 1984, as the Space Station management concept emerged, has been on the definition of functional responsibilities at each organizational level with particular concern to the degree of delegation. A series of organizational meetings were held that at various times included the NASA Administrator, the Center Directors, the Associate Administrators, all key staff members in the Headquarters Office of Space Station, the Program Management organization at the lead center, and the key Space Station project managers at each major center. The interfaces between organizations at all levels have now been defined and are not expected to change significantly, at least through the program definition phase.

3.2 SELECTED APPROACH

This section describes the selected management and technical approach for achieving the Space Station Program goals and objectives. The approach reflects the results of the studies and analyses as well as the program concerns discussed previously. Management and engineering-related guidelines were developed — with the participation of potential customers — to ensure adherence to the original objectives as the Program evolves. The management related guidelines include a comprehensive definition phase lasting approximately three years with an investment of five to ten percent of the estimated cost of the initial Space Station capability. This definition phase will include a study of a user-friendly Space Station that is initially man-tended and will develop a plan for automation and robotics that achieves the most productive man-machine mix and promotes the advancement of automation technology for both space and ground based applications. The entire system will be customer-oriented in design and operating concept to ensure flexibility and simplicity of customer interfaces. A parallel Advanced Development Program will be conducted to provide enhancing and enabling technology design options for the initial Space Station. The Advanced Development Program will provide a bridge between advanced technology investigations and system development and implementation. This is done by utilizing test beds that demonstrate technology readiness and flight experiments to verify system design concepts.

The overall program management approach selected encompasses both NASA Headquarters and field center expertise with policy and overall program direction provided by NASA Headquarters, program management provided by the Johnson Space Center, and project management provided by designated field centers.

The development phase, including manufacture and assembly, will begin in 1987 with initial capability projected for the early 1990's. Extensive user community involvement will include technology, science and applications, commercial, and academic disciplines. International participation is expected in the development, user, and operations activities. The engineering guidelines include provisions for continuous habitation, Shuttle usage for initial launch, resupply, and crew rotation, cost reduction by maximizing commonality, evolutionary growth through maintainable and restorable systems, manned and unmanned elements, and autonomous operation with the ability to upgrade systems as new technologies become available and are needed.

3.2.1 Program Management - Levels A, B, and C

The selected approach establishes overall program policy and direction responsibilities at NASA Headquarters (Level A), program management and technical integration at the Lead Center (Level B), and element definition at the various development Centers (Level C). To clearly define the roles and responsibilities and provide for the distribution and control of funds among Levels A, B and C, a formal Program Initiation Agreement has been signed by the Level A Program Associate Administrator, the Level B Program Manager, and the Level B Center Director. Similar documentation for the agreements between Level B and the Level C Centers will be implemented. The specific organization and responsibilities of each management level are described below.

Approval by the Administrator or his designee is required to change any of the following controlled items: Program goals and objectives; magnitude or direction of the technical plan; major milestones; the Program cost; the annual funding plan; assignment of major management responsibilities to NASA centers and Headquarters offices; international agreements; and approved mission requirements.

3.2.2 Level A Program Direction

Level A program direction is provided by the Office of Space Station, a Program Office in NASA Headquarters. The Associate Administrator for Space Station, who is the Program Director, reports to the NASA Administrator. Level A is responsible for establishing overall Program policy guidelines, direction, and management including coordination with all external national, international, and commercial organizations. Specifically, Level A is responsible for providing overall Program direction and top-level requirements definition, technical, budget, schedule and cost controls, utilization and operations planning, and technology and advanced system planning.

3.2.3 Level B Program Management

Level B is responsible for providing overall Program management and integration. This includes molding the customer, operations, and engineering (advanced development and work packages) functions into a cohesive program. Level B is responsible for defining the interfaces between work packages and for conducting the SE&I for the Program. Level B will use the results of internal SE&I studies, Advanced Development Projects, and supporting studies performed by Level C Centers and their definition phase contractors to define the Space Station Program. Level B management will also coordinate the customer requirements to assure that the resulting Space Station design capability fulfills customer needs within the design-to-cost limitations. As an integral part of establishing a long-life, program operations functions will be defined and operations requirements will be considered in the design and development phase. This will include the continuing development of operations plans. Level B is responsible for Program-wide resource management, configuration management, documentation, performance management systems, and Program planning and scheduling, as well as the definition and development of a Technical and Management Information System (TMIS).

3.2.4 Level C Project Management

The Level C Project Management Centers are responsible for work package contract management, conduct of advanced development projects, providing SE&I support to Level B studies, and design, development and verification of all hardware and operations concepts.

Each center work package will consist of a collection of functions that in any design or development activity will evolve into hardware, software, and interfaces. The work packages that have been defined for the definition phase are as shown in Figure 3-1.

3.2.5 Advanced Development

The Advanced Development Program provides development of promising technologies for potential application in the initial Space Station and the evolutionary Space Station. The program consists of the following key elements:

- Focused Technology - to provide a clear and proper application focus to selected technology disciplines primarily resident in the generic base research and technology programs.
- Prototype Technology - to develop promising technology advancements into prototype components and subsystems for test and demonstration.
- Test Beds - to integrate prototype hardware and/or software for testing at the subsystem level, and evaluate the potential of these options for application in the initial and evolutionary stations.
- Flight Experiments - to validate the performance of critical components and subsystems in a space environment, and determine their feasibility for inclusion into the Space Station design.

FIGURE 3-1

WORK PACKAGE SUMMARY DEFINITION

WP-01-MSFC	WP-02-JSC	WP-03-GSFC	WP-04-LeRC
SE&I SUPPORT	**SE&I SUPPORT**	**SE&I SUPPORT**	**SE&I SUPPORT**
• ECLSS ANALYSIS • LOGISTICS ANALYSIS • OMV/OTV INTERFACE ANALYSIS • COMMON MODULE COMMONALITY ANALYSIS • PROPULSION ANALYSIS • REBOOST ANALYSIS • LABORATORY ANALYSIS	• GROWTH ANALYSIS • DMS ANALYSIS • COMM/TRACKING ANALYSIS • LOADS ANALYSIS • THERMAL ANALYSIS • CONTROL ANALYSIS • ASSEMBLY SEQUENCE DEFINITION • STS PROXIMITY OPERATIONAL BERTHING ANALYSIS • CREW INTERFACE ANALYSIS • RESOURCE INTEGRATION ANALYSIS	• PLATFORM CONFIGURATION AND COMMONALITY ANALYSIS • PLATFORMS/SATELLITES SERVICING ANALYSIS • ATTACHED PAYLOADS ANALYSIS • LABORATORY ANALYSIS • STATION/PLATFORM INTERFACE ANALYSIS	• POWER SYSTEM ANALYSIS
HARDWARE/SOFTWARE	**HARDWARE/SOFTWARE**	**HARDWARE/SOFTWARE**	**HARDWARE/SOFTWARE**
• COMMON MODULE – STRUCTURE – DISTRIBUTION FOR: -- DMS -- POWER -- ECLSS -- THERMAL -- COMMUNICATIONS • ECLS SYSTEM • PROPULSION SYSTEM • LABORATORY MODULE OUTFITTING (1) LOGISTICS MODULE OUTFITTING (2 or 3) OMV/OTV ACCOMMODATIONS APPLICATIONS SOFTWARE	• ASSEMBLY STRUCTURE – TRUSS – MODULE INTERCONNECT – AIRLOCK – STS BERTHING – PWR,THERM., GIMBALS • MANIPULATORS • RESOURCES INTEGRATION • THERMAL CONTROL SYSTEM • EVA SYSTEM AND AIRLOCK OUTFITTING • GUIDANCE, NAVIGATION AND CONTROL SYSTEM • COMM/TRACKING SYSTEM • DMS • HABITAT MODULE OUTFITTING • STS INTERFACE • APPLICATIONS SOFTWARE	• PLATFORMS • ATACHED PAYLOAD ACCOMMODATIONS • PLATFORM AND FREE FLYER SERVICING ACCOMMODATIONS • LABORATORY MODULE OUTFITTING (1) • APPLICATIONS SOFTWARE	• POWER SYSTEM – GENERATION – CONDITIONING – STORAGE • APPLICATIONS SOFTWARE

DSC-1284

Advancement of current state-of-the-art technology in selected disciplines is required to meet Agency goals for the Space Station, both in the initial configuration and in the evolutionary growth configuration. The development and demonstration of this technology for the Space Station will build upon the Agency's generic research and technology base and will utilize the expertise of private industry and the NASA field centers. The Space Station Program will allocate a budget for the Advanced Development Program and will establish the necessary management and integration processes to ensure maximum benefit to the Space Station.

Responsibilities

Technology Discipline	Lead Center	Core/Supporting Centers
Attitude Control and Stabilization	MSFC*	JSC, JPL, LaRC
Data Management	JSC*	GSFC, MSFC, KSC, ARC, JPL, LaRC, NSTL
Auxiliary Propulsion	MSFC*	LeRC, JPL, JSC, ARC, GSFC
Environmental Control and Life Support	JSC*	ARC, MSFC
Structures and Mechanisms	MSFC*	JPL, JSC, LeRC, LaRC
Thermal Management	JSC*	GSFC, LeRC, MSFC
Electric Power	LeRC*	JSC, MSFC, JPL
Human Productivity	JSC	ARC, KSC, MSFC, JPL
Communications and Tracking	JSC	JPL, GSFC, LeRC, MSFC, LaRC

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* Test Bed Centers

The Lead Center is responsible for managing and integrating the task efforts for a given technology discipline across all participating Centers. The Lead Center is also responsible for developing and operating the technology test beds as assigned. These Center responsibilities will be defined in appropriate Project Initiation Agreements and plans being developed between Level B and the Level C Centers. This concept provides a close and effective tie between the system development responsibility of the lead center and the research capabilities of the supporting centers that supply major elements of the system for evaluation or validation.

3.2.6 System Engineering and Integration (SE&I)

The success or failure of the Space Station Program from a technical standpoint depends on the system engineering and integration (SE&I). For reasons explained below, NASA has decided to retain the management of this function within the Agency instead of delegating it to contractors. This decision is central to the technical management of the Program.

SE&I can be described as the end-to-end engineering and design of the modular Space Station and of the two space platforms that are contemplated. SE&I comprises all of those efforts that focus on the final products of the Program — the actual hardware that is placed in orbit. Therefore, SE&I must address:

- Definition of physical requirements to reflect mission requirements (such as specific customer requirements);
- Overall systematic operation of the major components of the Space Station and other vehicles; and
- Integration of all components to ensure proper assembly and operation; this is the so-called "interface engineering" that ensures a proper marriage of all subsystems (electrical, mechanical, etc.) and components.

The system requirements are inputs to conducting systems analysis, systems trades, configuration analysis, maintainability analysis, STS integration, and logistics analysis. Systems integration provides requirements integration, Interface Control Documents (ICDs), configuration management, specifications, and commonality. The end products of SE&I during the definition phase are the designs, specifications, manufacturing and test plans, cost estimates, and schedules for the development phase.

The Level B Program Office at Johnson Space Center is responsible for establishing and managing the SE&I.

3.2.7 Technical and Management Information System (TMIS)

The Program will use a network of commercially-available hardware and integrated software to provide an information exchange among all elements of the Space Station Program. The need for the Technical and Management Information System is driven by the fact that the Space Station Program is more distributed across the Agency than any previous program and, accordingly, requires a timely and accurate integration of information.

The TMIS will provide technical engineering support for professional uses through data base interaction and computer-aided design; communications for document transmission, conference support, and networking; administrative support for general office functions; and a management information system that will support budgets, schedules, manpower, change control, and facilities.

3.2.8 Man-Tended Mode

In accordance with a congressional mandate, NASA is examining a man-tended Space Station option. A man-tended Space Station is one that phases in the permanently manned features over 3-5 years following initial deployment of the basic station. The necessary analyses and trades will be performed to fully characterize the man-tended option. These analyses will include the following activities to be carried out by the Phase B contractors:

- Analysis of the unique and common features the man-tended option would have in comparison to the permanently manned Space Station, including cost, risk and schedule trade-offs, from the standpoint of unmanned operations.
- Analysis of the growth factors which the man-tended option requires to accomplish a "phase-in" of the manned features necessary for a continuously habitable station, including the scar resulting from the evolution of man-tended to a permanently manned Space Station.
- Analysis which details the capabilities of a station that is initially man-tended for a period of three to five years to fulfill mission requirements as stated for the permanently manned Space Station.

Management of the contracted effort will be provided by the cognizant Level C Centers. Level B will provide the management integration to ensure that the analyses are coordinated and integrated into the mandated study.

NASA will submit the results of this study and those of other reference configuration studies to both Appropriations Committees for review prior to the selection by the Administrator of a configuration for the permanently manned Space Station and proceeding into design and development, Phases C/D. Recommendations for the configuration will be based on such criteria as overall growth capability, estimated costs, and fulfillment of customer needs.

3.2.9 Automation and Robotics

In response to a congressional request, NASA is sponsoring a one-year study to develop goals for automation and robotics for the Space Station definition. This study will determine:

- Level of relevant technologies available in early 1990's.
- Potential for such technologies to perform generic Space Station operations.
- Areas in which advances of these technologies will enhance the nation's technical and scientific base leading to more productive U.S. industries.
- Information and breakthroughs needed to automate those man-assigned functions that can be automated.

The California Space Institute (CSI) has organized a university-industry team to guide a comparative effort of systems design and systems technology. The Stanford Research Institute performs technology forecasting. Five aerospace companies are examining the design implications of the technology analysis. The resulting automation plan submitted by CSI is being reviewed by the Space

Station Advanced Technology Advisory Committee (ATAC) for input to the Level B Space Station office. The resulting ATAC report will be provided to Congress and the contractors selected for the preliminary design studies. The contractors will use the report in developing automation and robotics plans. The primary objective is to characterize the nature and magnitude of automation and robotics at each proposed step of evolutionary growth of the Space Station in such a way as to attain the most productive man-machine mix and simultaneously, to identify the Space Station systems that represent the most promising opportunities for the advancement of automation technology both in space and on the ground. Supporting documentation for this plan includes descriptions of the partitioning of man-machine roles, technology availability, roles of artificial and expert systems, technical content and performance capabilities, relevant trade studies, and those technology areas that will contribute to the national technical and scientific base and enhance the productivity of terrestrial applications.

3.2.10 Technology Transfer

NASA has more than 26 years' experience in carrying out international cooperative programs, and has achieved meaningful international participation in the U.S. civil space program without prejudicial effects on the integrity of U.S. technology. It is NASA's policy to encourage the domestic dissemination of technology to enhance the competitive posture of U.S. industry and, at the same time, to prevent the loss of sensitive technology to international adversaries or competitors that would compromise either national security or continued U.S. economic growth.

Cooperation in NASA's space programs takes place on a government-to-government basis. The intent is to work across clean technical interfaces to minimize the amount of information which has to be transmitted to the foreign partners. Therefore, NASA will structure its cooperative agreements to achieve these clean technical interfaces, and the international partners will assume full technical responsibility for developing their projects.

NASA will follow the same pattern for Space Station that it has followed for the past 26 years; NASA will develop its portion of the Space Station by issuing contracts to U.S. industry. Contractor/ subcontractor relationships between U.S. industry and foreign industry are outside the government-to-government cooperation in which NASA is directly involved. It will be the responsibility of any U.S. entity entering into relationships with foreign entities to comply with applicable statutes and regulations regarding export licensing.

A technology transfer control plan for Space Station is being prepared to augment existing NASA guidelines for the Program.

3.3 DISCUSSION OF PROGRAM MANAGEMENT RISK

In developing the program management organization and plan, consideration was given to program characteristics which could, if left unattended, develop into major problems. These areas of vulnerability have been categorized as management and technical "risks." Sections 3.3 and 3.4 discuss these "risks" and summarize some of the management steps that have been developed to assure that the "risks" do not mature into problems.

3.3.1 National Goals

The Administration firmly believes that the national goal of a permanently manned Space Station, developed by the early 1990s, is the next logical step for the U.S. civil space program. The establishment of a permanently manned Space Station will be a challenging management task. However, the experiences of the civil space program over the last 26 years provide an impressive track record for the United States. The real risk in the development of a Space Station is that the Program might not maintain overall U.S. leadership, that it might not meet the needs of the scientific, technical, and commercial users, and that the Space Station cannot be improved and used for an indefinite period. However, NASA believes that there exists the necessary management experience and expertise in the government and in the aerospace industry to ensure overall success in the formulation and execution of a Space Station Program that will meet national goals. The confidence of NASA is shared by key industry and science community individuals who have, to date, participated in the formulation of program plans. These views are predicated on the general assumptions of no major change in world political or economic situations and a stable pattern for the NASA budget over the next 10 years.

The national goal of exploiting the unique environment of space for commercial purposes is achievable over time, with little technical risk. NASA Headquarters has recently established the Office of Commercial Programs, whose prime responsibility involves the emphasis of Agency activities and programs that lead to increased commercial benefits from space flight. The primary risk to commercial users would be the possibility of inadequate return on investment. However, experience to date with the Space Transportation System and the mission requirements analyses for Space Station forecast significant eventual commercial use.

A major national goal is the stimulation of student interest in an engineering or science education. The Space Station will provide unique facilities and many new opportunities for scientific and engineering experiments in space for faculty and students because of its permanent nature. These factors, coupled with the high public visibility of the program, should provide a major stimulus to student interest in the nation's science and engineering education programs.

The goals for the Space Station include the participation by other countries. Preliminary planning for participation by the European Space Agency, (Federal Republic of Germany, Italy, France, the United Kingdom) Canada and Japan is already underway. Given their continued foreign participation in the Space Transportation System flights over the remainder of the decade, participation in the Space Station Program by international friends appears likely and productive.

3.3.2 Institutional Concerns

The long-term nature of the Space Station Program will require a well-documented corporate memory and a high level of engineering managerial continuity. Most previous NASA space flight development programs have depended on the contractor-supplied system engineering and integration (SE&I). The Space Station will be an evolving and long-duration facility that will be operated and enhanced for at least two decades. To avoid having this long-term space resource become "captive" to a particular contractor, to serve as a means of sustaining the in-house NASA civil service capabilities for SE&I, and to assure that NASA remains a "smart" buyer, the decision has been made to conduct the Space Station Program without using a prime contractor for the Program SE&I. The institutional risk in this approach is viewed as acceptable, given no appreciable cutback in authorized manpower. Inherent in this risk is NASA's capability to provide competitive salaries and benefits compared to high technology industries.

The division of main definition phase responsibilities into Work Packages to be managed by MSFC, JSC, GSFC, and LeRC, with technology support from the other centers, is expected to strengthen the cohesion of the entire Agency. A distributed approach induces a small increase in the possibility that design errors in one effort could impact on another area. These problems, however, should be manageable through the increased visibility provided by the TMIS and the mechanism of program management controls and Configuration Control Board (CCB) practices. The advent of computer-aided design and data systems network and data basing which will be used extensively by the Space Station Program should keep the technical design risk to a minimum.

The establishment of a "Lead Center" function (Level B Management) and its assignment at one of the NASA centers to perform the Program management, integration, and technical direction also reduces institutional risk by placing the responsibility at a Field Center with lead center experience. The specific functions of the Level B organization vis-a-vis NASA Headquarters and the Level C centers has been the subject of a management review and planning process conducted throughout 1984 within NASA.

3.3.3 Programmatic Risks

The current concept is for a Space Station Program consisting of two modules each for laboratory and habitat functions, two orbiting platforms, two or three logistics modules, and a crew of six to eight, although concepts other than this reference configuration are being studied. The current Program Definition and Preliminary Systems Design Request for Proposal (RFP) will result in contracts that better resolve the program content question over the next two years. This RFP also requires the analysis of an initially mantended version of the Space Station where permanent occupancy would occur later in the operation.

The timely achievement of Program objectives within target costs is a principal concern of the Associate Administrator for Space Station. Every possible effort is being made to define a design-to-cost program that will meet this objective. The design-to-cost goals of the program have been strongly stated in the definition phase RFP and cost control aspects of the proposals received will be an important consideration. However, the extensive and thorough definition and preliminary design process that NASA is devoting to the Program, along with the commitment to moderating the technical risks through the advanced development program, should result in a Program plan and cost estimate that will be relatively consistent throughout the acquisition and operation of the Space Station.

3.4 DISCUSSION OF PROGRAM TECHNICAL RISK

Technical risks are inherent in the development and application of a new technology or a new engineering design approach. During the Program Definition and Preliminary Design Phase, technical risks and resolution approaches will be defined through the combined activities of the advanced development program, supporting flight tests, SE&I, and contractor study efforts. A key mandate of NASA is to advance United States technology. Thus, technology development is a major consideration when conducting cost and schedule trade-offs.

The following summarizes examples of potential technical risks:

Verification: On-orbit protoflight testing of new technologies as well as ground testing and considerable analysis will be required. It must be expected that final verification on-orbit may reveal deficiencies that could cause additional redesign and thus impact cost and schedule.

Maintainability: The Space Station systems will be designed to be maintained in space while major systems continue to function. Risk will be associated with added complexity of design and necessary redundancy, especially for the fluid distribution systems where the possibility of leakage during maintenance may be increased.

Assembly and Mechanisms: The assembly of major components in orbit for the first time will present technical risks. Ground simulation and demonstration of berthing and docking are limited because of the effects of gravity.

The possibility of failures during the process of on-orbit assembly of the Space Station hardware will be studied during the definition phase. Some risks may be unavoidable during initial assembly should it be necessary to leave a partially assembled Space Station on orbit. Methods to control these unmanned assemblies and docking, berthing and associated mechanisms will be studied in the SE&I and advanced development projects.

Environmental Control and Life Support (ECLSS): Selection of advanced technology options for closed loop systems (oxygen generation, carbon dioxide removal, and water recovery) involves a tradeoff of cost and resupply risks. Options will be studied to define requirements for parallel technology developments that will allow selection of an optimum ECLSS.

Propulsion and Fluid Management: Systems that use cryogenic fluids at zero-g are difficult to design from the aspects of fluid handling, gauging, and transfer. Trade studies will be made to determine if performance increases (reduced resupply), and commonality with other systems offers benefits which outweigh the risks.

Power Generation: The technical trade-offs between using a solar-dynamic power system or a photovoltaic system for the initial Space Station design will be assessed. The solar-dynamic system is superior to the more conventional photovoltaic system in the areas of station control, proximity operations, and reboost, but is less well developed and, therefore, represents greater risk. The solar-dynamic system is also advantageous from the standpoints of growth and future technology. All of these factors will be considered in the selection of a power system during the definition phase.

Automation and Robotics: The plan to integrate robotics technology and to include appropriate levels of automation and autonomy is an important element of the design of the Space Station. It will require rigorous analysis of failure modes and effects for all critical systems to minimize the possibility of failures affecting crew safety and mission success. Intelligent selection of the proper mix of human and machine functions, combined with good design practices, can actually reduce risk as well as enhance productivity.

4.0 SPACE STATION HEADQUARTERS PROGRAM DIRECTION

The Office of Space Station was established at the National Aeronautics and Space Administration (NASA) Headquarters on August 1, 1984, to provide Level A direction to the Program. The Office is under the direction of the Associate Administrator for Space Station, who reports directly to the NASA Administrator (Figure 4-1). The relationships between the Office of Space Station and other NASA offices and Agency advisory panels are briefly described below.

- Office of Space Flight - The Office of Space Flight (OSF) is responsible for the Space Transportation System (STS) and will interface with the Space Station Program Office on all transportation requirements for the Space Station Program, and with Space Station users for payload transportation requirements.

- Office of Space Science and Applications - The Office of Space Science and Applications (OSSA) is responsible for the establishment of science and applications requirements, and the definition, design, and development of NASA science and applications payloads for the Space Station Program as well as for the scientific analysis and evaluation of the data from the Space Station and its associated platforms. This Office sponsored a series of summer studies by the Space Science Board and the Space Applications Board (National Academy of Sciences) to identify the requirements for science and applications missions that might be performed on a Space Station, or on free-flying satellites and platforms supported from a Space Station.

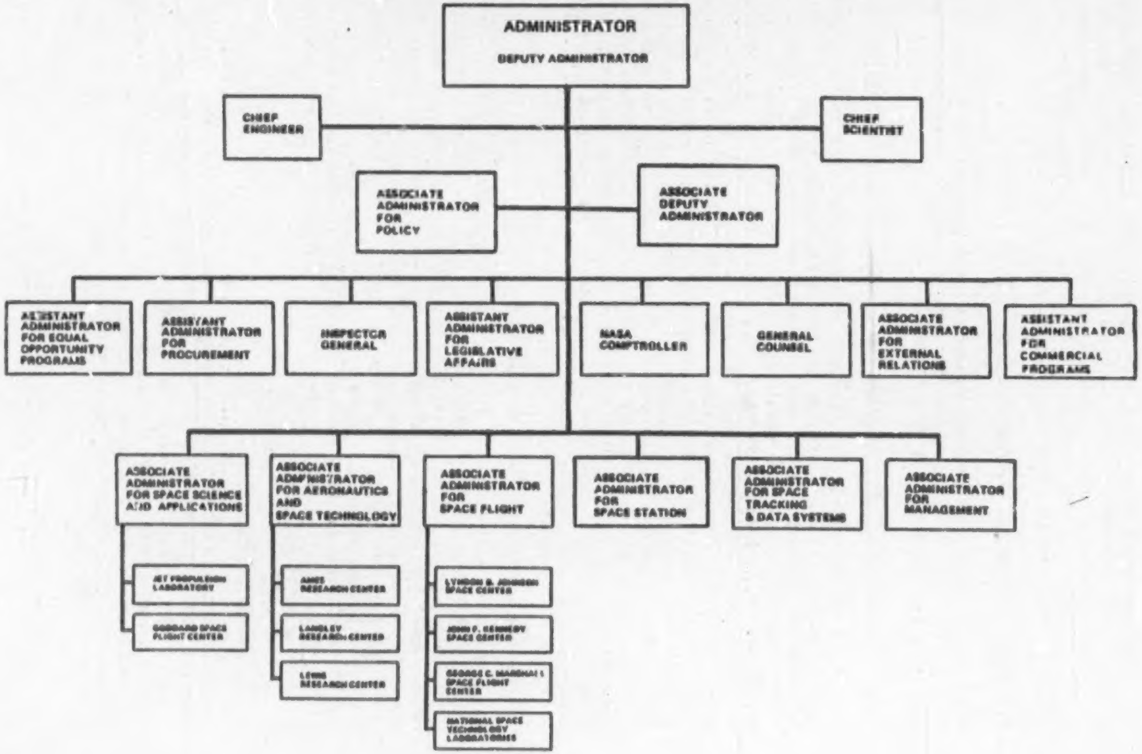
- Office of Aeronautics and Space Technology - The Office of Aeronautics and Space Technology (OAST) is responsible for the management and execution of generic technology and supporting studies applicable to the Space Station Program.

- Office of Space Tracking and Data Systems - The Office of Space Tracking and Data Systems (OSTDS) is responsible for the management, execution and operation of communication, tracking, data handling, data processing, and data distribution systems in support of Space Station, and for conducting technology experiments."

- Office of Chief Engineer - The Office of Chief Engineer will provide a corporate engineering, safety, reliability, maintainability, and quality oversight to the Space Station Program and will serve as advisor to the Administrator on matters pertaining to technical readiness and execution of the Program.

- NASA Advisory Council - The NASA Advisory Council and its standing committees in aeronautics, history, life sciences, space applications, space and earth science, and space systems and technology provide a comprehensive aeronautics and space program advisory structure to advise the NASA Administrator on NASA's aeronautics and space programs.

FIGURE 4-1
NASA HEADQUARTERS ORGANIZATION


ADMINISTRATOR
DEPUTY ADMINISTRATOR
CHIEF ENGINEER
CHIEF SCIENTIST
ASSOCIATE ADMINISTRATOR FOR POLICY
ASSOCIATE DEPUTY ADMINISTRATOR
ASSISTANT ADMINISTRATOR FOR EQUAL OPPORTUNITY PROGRAMS
ASSISTANT ADMINISTRATOR FOR PROCUREMENT
INSPECTOR GENERAL
ASSISTANT ADMINISTRATOR FOR LEGISLATIVE AFFAIRS
NASA COMPTROLLER
GENERAL COUNSEL
ASSOCIATE ADMINISTRATOR FOR EXTERNAL RELATIONS
ASSISTANT ADMINISTRATOR FOR COMMERCIAL PROGRAMS
ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS
ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT
ASSOCIATE ADMINISTRATOR FOR SPACE STATION
ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING & DATA SYSTEMS
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT
JET PROPULSION LABORATORY
GODDARD SPACE FLIGHT CENTER
AMES RESEARCH CENTER
LANGLEY RESEARCH CENTER
LEWIS RESEARCH CENTER
LYNDON B. JOHNSON SPACE CENTER
JOHN F. KENNEDY SPACE CENTER
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL SPACE TECHNOLOGY LABORATORIES

- Aerospace Safety Advisory Panel - The principal responsibility of the Aerospace Safety Advisory Panel is to review safety studies and operations plans referred to it, and advise the Administrator regarding the hazards of proposed operations and the adequacy of existing or proposed safety standards.

4.1 ORGANIZATION AND RESPONSIBILITIES

The Level A Space Station Program Office organizational structure is shown in Figure 4-2. The Level A offices described below are under the control of the Associate Administrator for Space Station.

4.1.1 The Office of the Associate Administrator for Space Station

The Office of Associate Administrator is responsible for the overall planning and direction of all elements of the Space Station Program. The Office develops and presents to the Administrator and other NASA officials detailed plans, schedules, and resource requirements for the accomplishment of the Space Station Program objectives. The Office establishes the program budget and allocates resources to meet approved objectives in accordance with delegated authority. In coordination with other Associate Administrators and Center Directors, the Associate Administrator for Space Station ensures that projects are assigned and implemented to carry out program objectives. The Office conducts advanced planning and follow-on activities to achieve improvements in costs and performance of the program. In coordination with other NASA offices, it develops and implements Space Station Program policies with other U.S. government, scientific, academic, and commercial customers and international participants.

4.1.2 Space Station Management Council

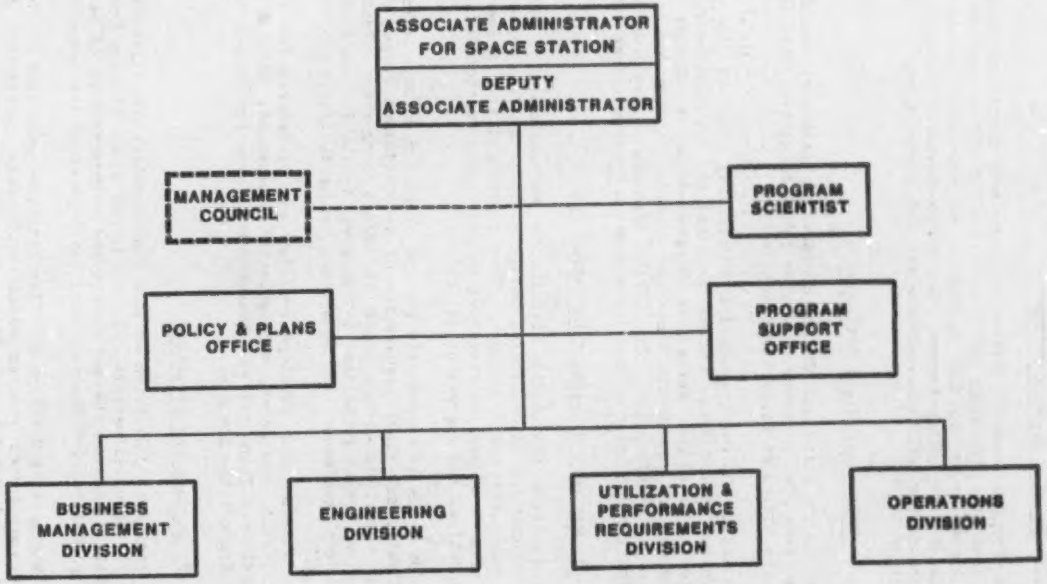
The Space Station Management Council was established on October 10, 1984 by the Associate Administrator for Space Station. The Council is to meet periodically to review policy decisions, broad program plans, and pending program commitments. The Council is chaired by the Associate Administrator for Space Station and membership consists of the Deputy Associate Administrator for Space Station, the Director for the Policy and Plans Office at Headquarters, the Level B Program Manager and Deputy Program Manager, and the Directors of the Goddard, Johnson, Kennedy, Lewis, and Marshall Centers. While not members of the Council, the Level C Space Station Project Managers are invited to attend the meetings.

4.1.3 Program Scientist

The Program Scientist is the resident science advisor to the Associate Administrator for Space Station. As the senior scientist in the Office of Space Station, the Program Scientist is responsible for refining and interpreting science requirements, contributing to the establishment of policy to ensure the requirements are fulfilled, overseeing implementation of the policy, and coordination with concerned Headquarter organizations as well as the external scientific community.

FIGURE 4-2

OFFICE OF SPACE STATION


ASSOCIATE ADMINISTRATOR FOR SPACE STATION
DEPUTY ASSOCIATE ADMINISTRATOR
MANAGEMENT COUNCIL
PROGRAM SCIENTIST
POLICY & PLANS OFFICE
PROGRAM SUPPORT OFFICE
BUSINESS MANAGEMENT DIVISION
ENGINEERING DIVISION
UTILIZATION & PERFORMANCE REQUIREMENTS DIVISION
OPERATIONS DIVISION

DSG-1129

4.1.4 Program Support Office

The Program Support Office provides administrative support to all of the offices and divisions of the Office of Space Station. The office makes recommendations to the Associate Administrator concerning management and organization policy issues. The office prepares and publishes management and organization policies, procedures, and instructions for the Office of Space Station.

4.1.5 Policy and Plans Office

The Policy and Plans Office advises the Associate Administrator and Deputy Associate Administrator on a wide range of matters both internal and external to the Office of Space Station.

The Office is responsible for integrating plans of the various NASA offices involved in the Space Station Program, and for strategic planning. In these roles, the Office keeps the Program Director abreast of current Program progress and constructs scenarios intended to keep him prepared for possible upcoming developments. The Office also undertakes technical analysis of the potential evolution of the Space Station Program in the future.

4.1.6 Business Management Division

The Business Management Division is responsible for policy, planning, and procedures for allocation of Office of Space Station resources and preparation of schedules and documents. This responsibility includes the analysis and assessment of program resources to meet Space Station definition, development, production, and operations objectives.

The Division is responsible for the overall planning, integration, evaluation, analysis, and final preparation of Space Station budget schedules and operating plans, including input to NASA's long-range planning. The Division develops budget guidelines for approval by the Program Director to guide Level B budget development and management responsibilities.

The Division also develops policies and procedures for performance measurement, cost management, configuration management, information management, and coordinates Technical and Management Information System (TMIS) planning with the Engineering Division.

4.1.7 Engineering Division

The Engineering Division advises the Associate Administrator for Space Station on all technical matters relating to the Space Station Program. This responsibility includes the definition and recommendation of policies, procedures, and guidelines for the technical development of the Space Station Program.

The Engineering Division provides technical oversight of Space Station activities, recommends program adjustments where appropriate to ensure that the design and development efforts for the Space Station are consistent with Program policies, and meet the established objectives and milestones. After the selection of the initial capability Space Station baseline configuration, the Engineering Division will direct studies to define growth options for the

Space Station. The Division oversees Space Station advanced development projects in coordination with the Agency's generic technology base.

In addition, the Engineering Division provides the leadership for human productivity efforts. The Division directs and oversees activities aimed at improving human productivity through the pursuit of human factors engineering, enhanced man-machine interfaces, the use of automation and robotics to relieve the human workload, and the study of on-orbit maintenance to achieve an indefinite lifetime for the Space Station.

The Division provides the Space Station Program technical interface with other NASA Headquarters offices, other U.S. government agencies, and foreign participants.

4.1.8 Utilization and Performance Requirements Division

The Utilization and Performance Requirements Division exercises the Level A direction of Program interactions with Space Station users or potential users in all sectors. The users include science, technology development, commercial, and applications (both experimental and operational). The users may be in government or the private sector including industry, academic institutions, and foreign or international organizations. Users will be identified and cultivated during the evolution of the Space Station through definition, development, and operations. The interests of the users will be represented to the Space Station Program, and the responses and technical and operational accommodations afforded by the Space Station in turn represented to the customers. The Division establishes the policies and directs the Level B activities of compiling requirements and needs of all customers, negotiating with customers, and synthesizing customer requirements into defined user missions, time-phased mission sets, performance requirements, and the necessary design operational capability for each phase of the growth of Space Station capability with close coordination of the appropriate program office. It is also responsible for baselining, updating, and controlling the Level A mission operations requirements, and generating and maintaining total Level A functional requirements.

The Division will sponsor the activities of a Mission Requirements Working Group (MRWG), a Commercial Advocacy Group (CAG), and similar groups both domestic and international. The Division manages advanced planning studies that relate stated or projected user requirements to advanced concepts, advanced technology programs, and development plans for the growth of Space Station capabilities. Included are studies and analyses of the effect of Space Station design, operational procedures, commercialization policies, and user charges on utilization effectiveness and user productivity. The Division works with other Divisions and Level B and Level C to assure fulfillment of requirements, develops user policies, explains or gives Space Station requirements on users to the users, interfaces with other NASA offices, government agencies, industry, academic, and foreign organizations on user-related activities.

4.1.9 Operations Division

A major goal for the Space Station is a highly efficient operation that is cost effective. Overall operational goals and objectives are to ensure that the system is operated for the benefit of the customers, ensure efficient and effective crew utilization and a safe operating environment, provide a cost effective ground support systems, and ensure the lowest practical cost to the user.

The Operations Division is responsible for overall Space Station Program operations policy and direction to Level B.

The Division provides direction for the definition of the operational requirement on the Program Elements and ground support systems such as prelaunch processing of Space Station Elements and payloads, on-orbit customer and Space Station operations, and logistics, maintenance, and training. It develops agreements on operations with NASA and non-NASA programs. The Division assesses the implementation of operational requirements and directives. The Division establishes the operational requirements for the growth Space Station.

4.2 LEVEL A PROGRAM DIRECTION, CONTROL, AND REVIEW PROCEDURES

This section describes the procedures for implementing Level A Program direction, review, reporting, and communication of Program information.

Program direction and control of policy, requirements, costs, and schedules are exercised by the Associate Administrator for Space Station by various mechanisms established with Level B. Some of the key mechanisms are:

- Major requirements and technical design reviews with support from the centers.
- A Program Initiation Agreement (PIA) is negotiated with Level B which defines Program roles and missions. This PIA forms the basis for Project Initiation Agreements that are negotiated between Level B and Level C. After adequate program definition, these agreements will be superseded by program and project plans.
- Level A requirements for systems, operations, and customers are contained in a program requirements document and form the basis for the more detailed requirements developed by Level B.
- Level A controlled milestones are established to form the schedule framework for the definition and development phases of the program.
- Level A financial operating plans are established on an annual basis to allocate resources consistent with Level B Program evaluations.
- A normal correspondence system is used for routine policy and direction to Level B and a program directive system is used to define special requirements, controls, and working relationships.
- A documentation system will provide Program direction, establish policy, guidelines, and requirements, provide control of resources, budget, and schedules, and allow a free flow of Program information.

The above mechanisms are managed by the appropriate Level A offices and are approved by the Associate Administrator for Space Station. Any changes are reviewed and approved in a controlled manner. The change control system will be tailored for each phase of the program and will become more rigorous as the requirements and design baselines become more mature.

Formal periodic reviews and reports will be provided by Level A and B participants to the Associate Administrator for Space Station. These reports include management and technical progress as well as cost, schedule, and milestone status. Major Program management reviews are held periodically at Headquarters and appropriate field centers.

4.3 LEVEL A CUSTOMER RELATIONSHIP

The Level A Utilization and Performance Requirements Division will speak for and to the customer to affect the capabilities that are designed into the Space Station. This will be a continuing process conducted through committees, studies, workshops. The committees currently involved include:

- Space Science Board (SSB): The Board acts as the focus of interest and responsibilities for the National Academy of Science and National Academy of Engineering Research Council in space science and seeks to establish necessary relationships with civilian scientists, stimulate research, promote coordination of scientific efforts, and provide advice and recommendations with regard to space science.

- Committee on Data Management and Computation (CODMAC): The CODMAC is a committee of the Space Science Board and was formed in 1978. CODMAC consists of scientists from various disciplines with extensive experience and knowledge in space-science data processing, management, and computer science. The scope of CODMAC considerations encompass all space acquired data. CODMAC is requested to examine the management of existing and future data acquired from spacecraft and associated computations in the areas of space and Earth sciences, and to make recommendations for improvements from the point of view of the scientific user.

- Space Applications Board (SAB): The SAB is concerned with practical applications of the Space Station in three principal areas: Remote sensing of land, oceans, and atmospheres, satellite communications, and microgravity involving materials processing.

- Aeronautics and Space Engineering Board (ASEB): The ASEB was established at the request of NASA to conduct periodic assessments of programs in aeronautics and space technology and engineering. The ASEB maintains a continuing awareness of major problems and progress in aeronautics and space and recommends and/or undertakes appropriate action to ensure that the nation's efforts are responsive to changing needs and opportunities in these fields.

- Task Force on Scientific Uses of the Space Station (TFSUSS): The TFSUSS was established under the NASA Advisory Council (NAC) Space and Earth Science Advisory Committee to counsel NASA on plans for and work in progress on the scientific utilization of new capabilities that will be afforded by the Space Station, including the relationship of these plans to the existing Space Science Program.

- A Space Station study group has been formed by the Aerospace Industries Association (AIA) and will be filling an advisory role to the Administrator in the areas of development, operation, and utilization. The AIA will continue to advise the Administrator in the areas of development, operation, and use.

5.0 LEVEL B JOHNSON SPACE CENTER (JSC) PROGRAM MANAGEMENT AND INTEGRATION

In February 1984, the NASA Administrator assigned the Johnson Space Center (JSC) as the "Lead Center" for Space Station to provide program management and integration, budget, and technical controls. Subsequently, a Level B Program Manager was appointed and a Program Office (Figure 5-1) was established to accomplish this function. While Level A provides broad guidance and Level C develops hardware, the Program Manager at Level B insures that all technical, cost, and schedule goals of the Program are achieved. The Program Manager implements the policies of Level A and integrates, directs, and controls the activities of Level C elements. The Program Manager reports to the JSC Center Director and utilizes the full technical and management capabilities for Program formulation, implementation, and control.

Level B basic responsibilities include the following:

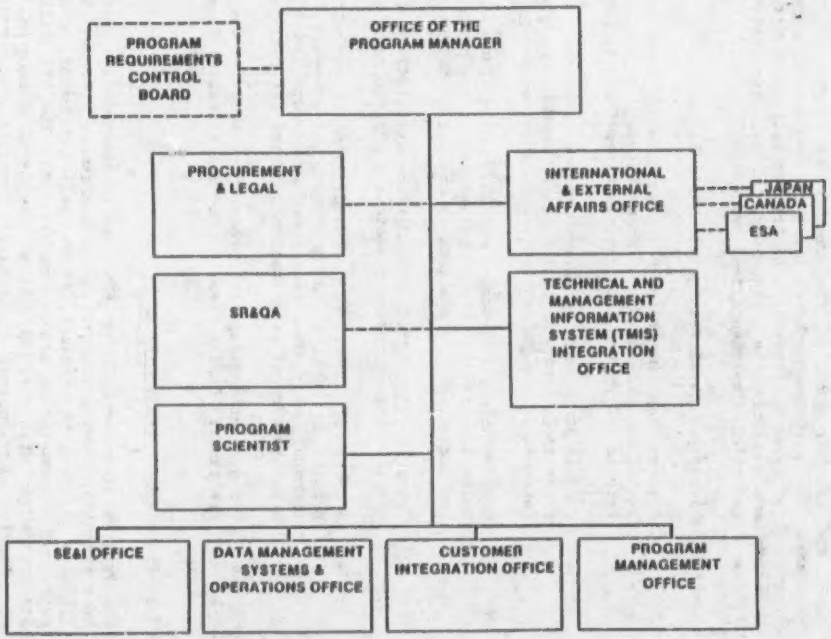
- Systems Engineering and Integration - Establish and manage the technical content of the Space Station Program, in response to the Program and system requirements established by Level A.
- Program Management - Manage Program resources and schedules, configuration, Program planning, documentation, directives, and performance to the budget and schedule guidelines provided by Level A.
- Data Management Systems and Operations Integration - Ensure the Space Station operations considerations are properly incorporated in the derivation of requirements and design of the system.
- Customer Integration - Manage the integration of customer requirements to ensure customer needs are a pervading program influence.
- Support of Level A - Provide overall technical and management support to Level A during budget and schedule formulation, establishment of system requirements, interaction with customers, and other aspects of program direction and external interfaces.
- Procurement - Manage the procurement activity for the Definition and Preliminary Design Phase of the Space Station Program.

5.1 PROGRAM MANAGEMENT OFFICE

The Program Management Office (PMO) is responsible for Space Station management planning, program resources, and management systems. This responsibility includes the program schedule, performance management, configuration management, and documentation management systems. The PMO will manage the Space Station budget with the approval of the Level B Program Manager, recommend distribution of resources among Level C centers, and support Level A. The overall Space Station Program schedule will be maintained, evaluated and controlled by the PMO. This will involve the integration of Levels A, B, and C activities as well as those of other participating national and international organizations. A performance management system (PMS) will be implemented to measure the progress of Space Station elements of work. A work breakdown structure (WBS) will be developed that displays all program elements.

FIGURE 5-1

SPACE STATION LEVEL B ORGANIZATION


OFFICE OF THE PROGRAM MANAGER
PROGRAM REQUIREMENTS CONTROL BOARD
PROCUREMENT & LEGAL
INTERNATIONAL & EXTERNAL AFFAIRS OFFICE
JAPAN
CANADA
ESA
SR&QA
TECHNICAL AND MANAGEMENT INFORMATION SYSTEM (TMIS) INTEGRATION OFFICE
PROGRAM SCIENTIST
SE&I OFFICE
DATA MANAGEMENT SYSTEMS & OPERATIONS OFFICE
CUSTOMER INTEGRATION OFFICE
PROGRAM MANAGEMENT OFFICE

Technical and management program requirements will be placed under a Level B Configuration Control Board (CCB) chaired by the Level B Program Manager.

A documentation system will define and describe program requirements, plans, results, management and technical information. The Level B documentation system will implement program directives, policy, guidelines, and requirements; provide control of Interface Control Documents (ICDs), resources, budget, and schedule; and provide for the flow of program information.

A program directives system is employed to provide formal direction from Level B to all subordinate organizations, working groups, and committees. These directives are designed to control requirements, configuration, program management processes, and other management or technical activities.

Management reviews and reports will be provided by Level B to Level A and will incorporate analysis of data from all Level C projects. Project reviews will be held involving the Level A Program Associate Administrator, and Level B and Level C managers.

A system of management agreements, plans, and requirements will be established to provide direction and responsibilities. A Program Initiation Agreement has been approved establishing top level responsibility agreements between Level A and B. Similar Project Initiation Agreements will be established between Level B and the Level C centers. These agreements at Levels A/B and B/C will be followed by Program and Project Plans that will describe in more detail the tasks and subtasks, organization structure and responsibility, and resources and schedule estimates. These plans will be used by the Program Manager to measure program progress. A Program Planning Team will be established at Level B to manage the preparation of these planning activities and coordinate the agreements among the centers. Representation on this team will be from all Level C centers, Level A, and will be managed by Level B.

5.2 SYSTEMS ENGINEERING AND INTEGRATION (SE&I) OFFICE

JSC will provide the majority of the Space Station SE&I by utilizing in-house civil service staff. It will be the responsibility of the Level B SE&I Office to ensure the technical integrity of the entire Program. Not only does this include the integrity within and among work packages, but also the assurance that NASA in-house efforts are technically comparable with the rest of the Program.

Level B is also responsible for integrating customer and operations requirements and defining systems requirements in order to provide system definition and design that fulfills user needs. In order to accomplish this responsibility, Level B has established suboffices for systems analysis, integration, and advanced development. These offices are responsible for integrating the activities of the Level C centers that have work package, advanced development and other technical and management supporting responsibilities. Technical Area Managers (TAMs) have been appointed for managing each of the Space Station systems and technical areas. They are responsible for seeing that the tasks required in their areas are done in a planned manner by Level B or Level C centers in an integrated manner. Their efforts are integrated at Level B to ensure that overall configuration and design results satisfy Program requirements.

This integration process will occur for the Definition and Preliminary Design Phase through a series of studies that result in the design reviews described earlier and shown on the milestone schedule. Each of these reviews is defined to bring together the results of operations studies, systems and subsystems tradeoffs, advanced development projects and designs, and the program and user requirements. The results of these reviews will be configurations, designs, interfaces, and the documentation and decisions necessary to proceed to the next phase. Each review will develop the design of the station to a greater level of detail so that when the systems design review is completed there will be high confidence in the cost and schedule and the overall Space Station design capability.

Once the design is established, configuration control boards will strictly maintain the configuration, design, documentation, and interfaces in order to ensure that the program meets cost, schedule, and capability requirements.

5.3 DATA MANAGEMENT SYSTEMS AND OPERATIONS

This Office will perform a systems engineering and integration function for the data management and operational functions of the program. These functions include prelaunch test and verification of Program elements and customer payloads; station maintenance and logistics resupply; data management definition, development, and integration across the Space Station and its supporting elements, including customer accommodations; crew interface and accommodations requirements; and operations integration of Space Station and Space Transportation System (STS) resources with customer requirements.

The Space Station will make use of automated data handling techniques and be user friendly. It will be largely autonomous (from the ground) wherever practical and cost effective, and maintainable in such a manner as to provide significant growth potential.

Additional functions include the operations integration requirements for the growth of the Station, from first launch and assembly to the final configuration and integration of potential flight test operations.

5.4 CUSTOMER INTEGRATION OFFICE

Customer requirements will be defined and integrated into the Space Station design and operation by the Customer Integration Office. Known customer requirements for such services as thermal control, power, pointing, etc., will be included in the designs of the initial and growth versions. Future requirements will be projected and accommodated to the extent that they are technically and economically feasible.

Customer representative panels composed of NASA, industry, university, and international personnel will be formed to ensure that customer technical and operational needs and desires are considered and to ensure that all necessary contracts, agreements, and memoranda of understanding are completed and mutually acceptable. It will be the responsibility of this Office to ensure that the Systems Engineering and Integration (SE&I) and Data Management System (DMS) Offices receive such technical and operational requirements, and that potential customers are aware of the opportunities provided by the Space Station. The Customer Integration Office is responsible for interfacing with similar offices at Level A for overall customer policy, and with Level C for implementation of requirements into design capability.

5.5 OFFICE OF LEVEL B PROGRAM SCIENTIST

The Office of Level B Program Scientist has been established to ensure the scientific user requirements of the Space Station are defined and incorporated into the Space Station design studies. This Office will also provide scientific support to the Space Station design from a technical-scientific point in such areas as environmental effects. The Program Scientist will work very closely with the Customer Integration Office and the Program Scientist at Level A, the Utilization and Performance Requirements Division of Level A, and the appropriate Program Office to ensure the customer's interest is well represented within the cost and schedule guidelines.

5.6 TECHNICAL AND MANAGEMENT INFORMATION SYSTEM (TMIS) INTEGRATION OFFICE

The Technical and Management Information System (TMIS) Office responsibility is to optimize the use of automated systems (hardware and software) during the Space Station Program. The TMIS Office will integrate the generation, transmission, and use of technical and management information. Compatibility between technical and management data processing will be a requirement, as will flexibility for growth as the Program evolves.

5.7 INTERNATIONAL AND EXTERNAL AFFAIRS OFFICE

The Level B International and External Affairs Office will provide an interface with the overall systems engineering and integration activities and the international community. This Office will support the international negotiations for Space Station agreements by providing information to the international community on the definition phase studies being conducted, the operations planning, and the customer integration activities. The international participation interest will be identified and will be treated similar to the other Level C work packages. Formal liaison will be established to provide technical information exchange, establish a configuration data base, and manage a change control system.

6.0 LEVEL C FIELD CENTERS PROJECT MANAGEMENT

Level C field centers provide project management for element definition and contractors; conduct technical studies; and support Level B in program activities, including technical and programmatic reviews, reports, agreements, and assessments. Regarding the Systems Engineering and Integration activity, all Level C field centers will support Level B according to their expertise and contractors.

Level C projects will be responsible for definition contract management, special systems and subsystems studies, user-interface requirements, operations support, advanced development test beds, design development and verification of all hardware, business management of the projects, and management of all element design and development contractors. Level C centers provide the technical management and integration for the various work package elements of the program and provide support to Level B for program activities. Typical program management activities include preparation and submittal of reviews and reports for visibility and tracking purposes, compliance with program directives, maintenance of documentation and information systems, and compliance with the Level B-approved work breakdown structure. Each Level C center will be responsible for ensuring the customer friendliness of its assigned elements. Specific responsibilities for hardware design and development will be made when the design is established. The Level C project organizations described below have been established to meet the needs of the definition phase. As the Program becomes fully defined and moves toward the design and development phase, the center organizations will evolve to meet existing Program requirements.

6.1 GEORGE C. MARSHALL SPACE FLIGHT CENTER

The Marshall Space Flight Center (MSFC) is responsible for the logistics analysis, Orbital Maneuvering Vehicle (OMV) and Orbit Transfer Vehicle (OTV) interface definition, and environmental control and life-support analysis, as well as common module commonality analysis, propulsion analysis, and laboratory outfitting analysis.

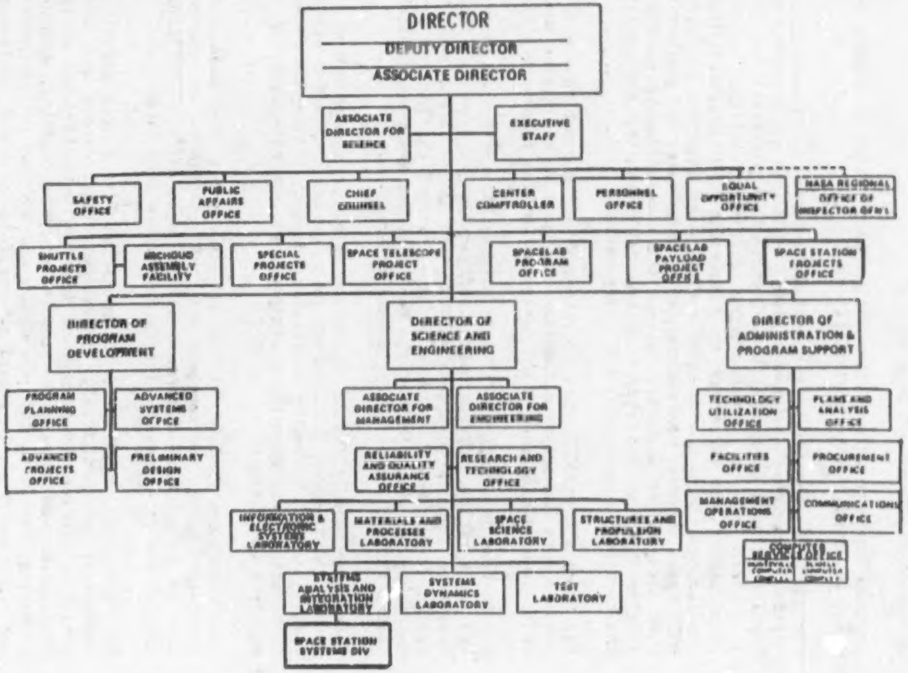
The MSFC Work Package includes the analysis, definition, design, and integration of the Space Station common module with its associated subsystems. This includes network distribution systems, which include primary and secondary structure, environmental control and life support, data management, electrical power distribution, thermal management, and communications. The Work Package also includes definition, design, and integration of the environmental control and life support subsystem, laboratory module outfitting, logistics module, propulsion system, and OMV and OTV accommodations.

In the Advanced Development activity, MSFC has Lead Center responsibilities in the areas of attitude control, auxiliary propulsion and fluids, and structures and mechanisms. MSFC has a supporting role in the areas of power, data management, thermal control, manned systems, communications, and environmental control and life support.

MSFC has established a Space Station Projects Office (SSPO) that reports directly to the Center Director, as depicted in the MSFC organization chart (Figure 6-1). The SSPO is the focal point for management of all activities

FIGURE 6-1

GEORGE C. MARSHALL SPACE FLIGHT CENTER


DIRECTOR
DEPUTY DIRECTOR
ASSOCIATE DIRECTOR
ASSOCIATE DIRECTOR FOR SCIENCE
EXECUTIVE STAFF
SAFETY OFFICE
PUBLIC AFFAIRS OFFICE
CHIEF COUNSEL
CENTER COMPTROLLER
PERSONNEL OFFICE
EQUAL OPPORTUNITY OFFICE
NASA REGIONAL OFFICE OF INSPECTOR GEN'L
SHUTTLE PROJECTS OFFICE
MICHOUD ASSEMBLY FACILITY
SPECIAL PROJECTS OFFICE
SPACE TELESCOPE PROJECT OFFICE
SPACELAB PROGRAM OFFICE
SPACELAB PAYLOAD PROJECT OFFICE
SPACE STATION PROJECTS OFFICE
DIRECTOR OF PROGRAM DEVELOPMENT
PROGRAM PLANNING OFFICE
ADVANCED SYSTEMS OFFICE
ADVANCED PROJECTS OFFICE
PRELIMINARY DESIGN OFFICE
DIRECTOR OF SCIENCE AND ENGINEERING
ASSOCIATE DIRECTOR FOR MANAGEMENT
ASSOCIATE DIRECTOR FOR ENGINEERING
RELIABILITY AND QUALITY ASSURANCE OFFICE
RESEARCH AND TECHNOLOGY OFFICE
INFORMATION & ELECTRONIC SYSTEMS LABORATORY
MATERIALS AND PROCESSES LABORATORY
SPACE SCIENCE LABORATORY
STRUCTURES AND PROPULSION LABORATORY
SYSTEMS ANALYSIS AND INTEGRATION LABORATORY
SYSTEMS DYNAMICS LABORATORY
TEST LABORATORY
SPACE STATION SYSTEMS DIV
DIRECTOR OF ADMINISTRATION & PROGRAM SUPPORT
TECHNOLOGY UTILIZATION OFFICE
PLANS AND ANALYSIS OFFICE
FACILITIES OFFICE
PROCUREMENT OFFICE
MANAGEMENT OPERATIONS OFFICE
COMMUNICATIONS OFFICE
COMPUTER SERVICES OFFICE

pertaining to the project. The SSPO is supported by the Science and Engineering Laboratories in the definition, design, and development activities. Within the System Analysis and Integration Laboratory a Space Station Systems Division has been established to provide the systems engineering of MSFC Space Station activities. The Administrative and Program Support Directorate provides the required procurement support.

The Space Station Projects Office organization is depicted in Figure 6-2 and SSPO functional responsibilities are as follows:

- The SSPO is responsible for overall project management for Space Station activities assigned to MSFC. This includes providing the Level B Program Manager with MSFC project requirements for integration into program requirements; providing policy, priorities, requirements and schedules to supporting MSFC organizations; approving, validating, and coordinating plans prepared by supporting MSFC organizations; controlling costs, schedules, and performance of MSFC assigned responsibilities and their relationship to the Space Station Program; and approving technical baseline and controlling the technical progress of MSFC assignments.

- The Program Control Office is responsible for establishing resource requirements and budget allocations, scheduling and status analysis, contract data management, and management of the information system.

- The Program Integration Office is responsible for system engineering and integration; operations; configuration management including Interface Control Documents (ICD's) and change board number; advanced development; customer utilization and the Mission Requirements Working Group (MRWG); the Technical and Management Information System (TMIS); and verification and safety.

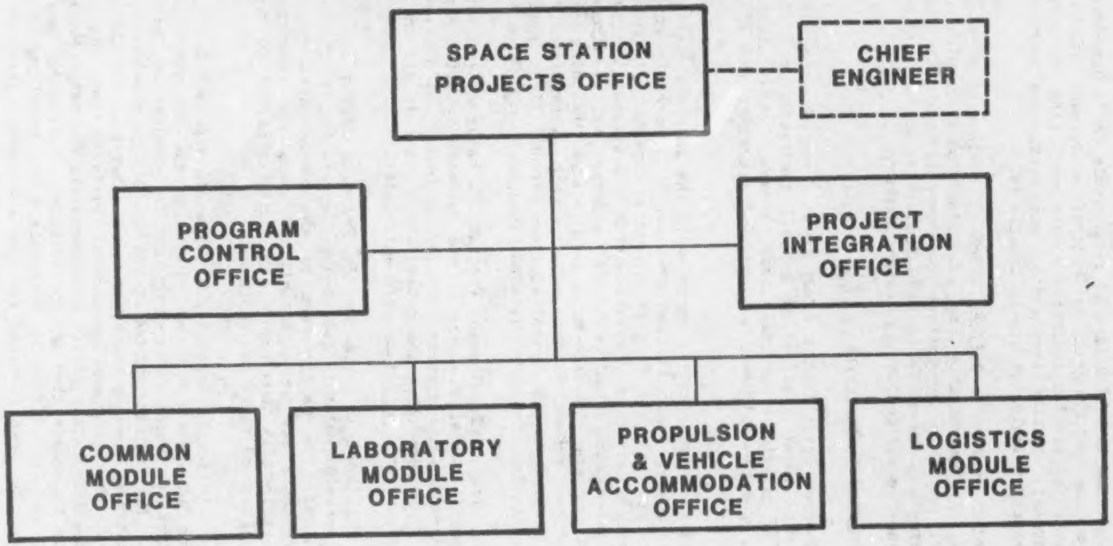
- The Common Module Office is responsible for management of common module requirements definition; in-house and contracted effort for common module, including definition, design, development, testing, fabrication, and sustaining engineering; and management of common module interfaces.

- The Laboratory Module Office is responsible for management of laboratory module requirements and configuration definition; management of definition contractors and in-house efforts for laboratory module; and management of laboratory module interfaces.

- The Propulsion and Vehicle Accommodation Office is responsible for management of functional, operational requirements and comparison/trade studies; management of in-house and contracted design and development; management of propulsion system testing, mockups and technology readiness for propulsion and OMV and OTV accommodation; and management of integration, verification, and implementation plans.

FIGURE 6-2

GEORGE C. MARSHALL SPACE FLIGHT CENTER
PROGRAM DEVELOPMENT
SPACE STATION PROJECT OFFICE


SPACE STATION PROJECTS OFFICE
CHIEF ENGINEER
PROGRAM CONTROL OFFICE
PROJECT INTEGRATION OFFICE
COMMON MODULE OFFICE
LABORATORY MODULE OFFICE
PROPULSION & VEHICLE ACCOMMODATION OFFICE
LOGISTICS MODULE OFFICE

- The Logistics Module Office is responsible for management of logistics module requirements definition; management of in-house and contracted effort for logistics module outfitting, including design, development, testing production, and sustaining engineering; and management of logistics module interfaces.
- The Chief Engineer's Office, which is co-located with the Project Office, is responsible for providing Space Station engineering effort; ensuring appropriate support for the S&E laboratories; providing S&E interface to MSFC Space Station Projects Office; and coordinating and conducting design reviews.

6.2 LYNDON B. JOHNSON SPACE CENTER

The Lyndon B. Johnson Space Center (JSC) Level C organization will provide support to the NASA Level B effort of overall configuration definition and assembly analysis; growth, structural loads, thermal, and control analysis; data management, end-to-end communications and tracking; and STS and crew interface analysis.

The JSC work package responsibility encompasses the analysis, definition, and design of the following Space Station systems: the assembly structure and devices necessary to tie all Program elements together, including module interconnect devices, airlocks, heat-rejection subsystems, attitude-control subsystem, propulsion subsystem, mechanical systems, and resources integration. Also included are the data-management system including application-software integration; communications and tracking systems; extravehicular activity (EVA) systems; Space Transportation System (STS) interface; and habitat module outfitting, including internal-equipment definition and design.

In support of the Advanced Development Program JSC has the lead activity for the data management, thermal management, and regenerative life support test beds, communications, manned systems, and EVA systems. JSC's organizational elements also will be supporting the other lead centers in all the test bed, focused technology, and flight experiments activities.

The Manager of the Level C Space Station Projects Office at JSC reports directly to the Center Director (Figure 6-3). Support for the Projects Office activities is provided in matrix form by the center line organizations. General work agreements are being established among the organizations for support, and specific task agreements will be established to control the month-to-month progress of tasks and subtasks.

The Level C Project Office is organized as shown in Figure 6-4. The Project Engineering Office prime responsibility is to manage the JSC work package projects and Definition Phase contractors and to provide the focus for the overall planning. The Engineering and Operations Office provides support for Level B SE&I activities, manages the systems and subsystems for the Definition Phase contractors, the Advanced Development projects and the operations planning. The User Integration Office is responsible for interfacing with the customer community to ensure that JSC projects are fulfilling requirements. The Manufacturing and Test Office is responsible for providing the manufacturing and verification test planning for the development phase of the program.

FIGURE 6-3

LYNDON B. JOHNSON SPACE CENTER

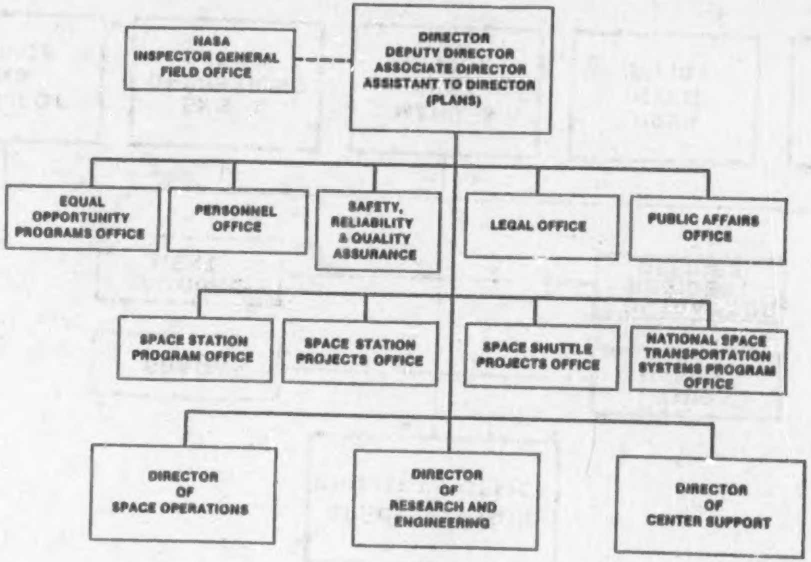
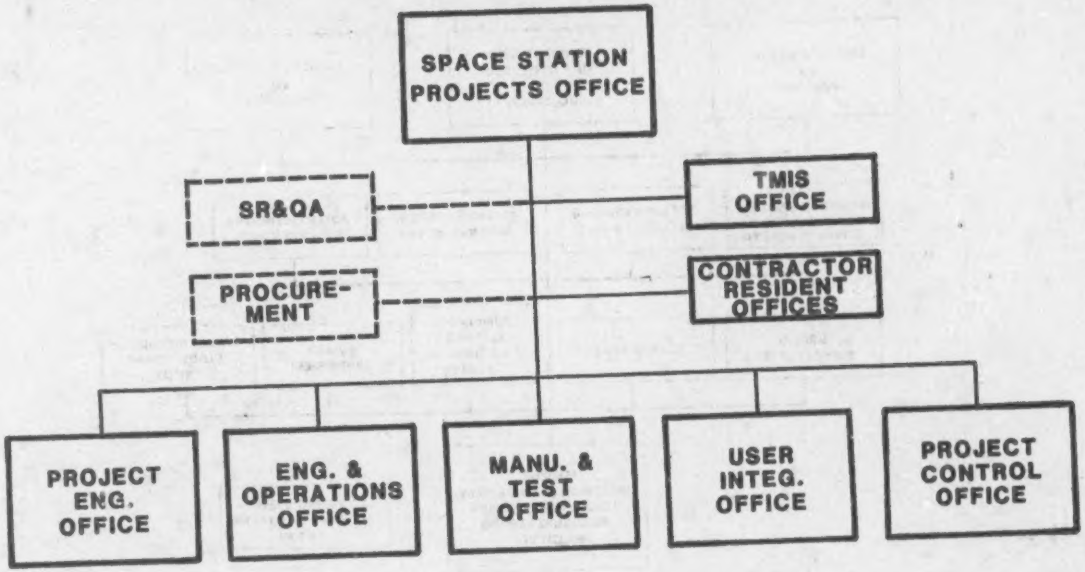

NASA INSPECTOR GENERAL FIELD OFFICE
DIRECTOR
DEPUTY DIRECTOR
ASSOCIATE DIRECTOR
ASSISTANT TO DIRECTOR (PLANS)
EQUAL OPPORTUNITY PROGRAMS OFFICE
PERSONNEL OFFICE
SAFETY, RELIABILITY & QUALITY ASSURANCE
LEGAL OFFICE
PUBLIC AFFAIRS OFFICE
SPACE STATION PROGRAM OFFICE
SPACE STATION PROJECTS OFFICE
SPACE SHUTTLE PROJECTS OFFICE
NATIONAL SPACE TRANSPORTATION SYSTEMS PROGRAM OFFICE
DIRECTOR OF SPACE OPERATIONS
DIRECTOR OF RESEARCH AND ENGINEERING
DIRECTOR OF CENTER SUPPORT

FIGURE 6-4
LYNDON B. JOHNSON SPACE CENTER
LEVEL C PROJECTS OFFICE


SPACE STATION PROJECTS OFFICE
SR&QA
TMIS OFFICE
PROCURE- MENT
CONTRACTOR RESIDENT OFFICES
PROJECT ENG. OFFICE
ENG. & OPERATIONS OFFICE
MANU. & TEST OFFICE
USER INTEG. OFFICE
PROJECT CONTROL OFFICE

The Project Control Office functions coordinate the definition of costs and schedules of the work package functions and elements. These estimates and the Work Breakdown Structure (WBS) will be used as a system to manage the definition, design, and development of the work package system, subsystem and components tasks. The information will be provided to the Level C responsible managers through the TMIS Office to allow them to manage project progress and make the necessary control decisions.

6.3 KENNEDY SPACE CENTER (KSC)

The Kennedy Space Center (KSC) will support Level B by detailing selected personnel to support the Level B organization. Assignments will include the functions of ground operations, logistics, data management, resources, scheduling and configuration management.

During the definition phase, KSC will also perform the definition of ground systems and ground operations. This will include the definition of launch site facilities. KSC will provide support to other centers such as logistics planning and analysis for the MSFC work package and high order computer language definition for the JSC work package.

KSC supports the Advanced Development Program in certain areas. Specifically, KSC currently is performing a study of an advanced Space Station operations language for use in interfacing with computers, a study of Space Station contamination control systems, as well as conducting generic and applied technology tasks which will eventually benefit the Space Station.

KSC's Space Station management activities have been assigned to the Space Station and Advanced Projects Office. Figures 6-5 and 6-6 show the overall KSC organization and the detail level organization of the KSC Space Station Level C Project Office.

KSC's manager of Space Station activities reports directly to the center director. Other center functional elements provide support to the Space Station Phase B activities in response to tasks as assigned by the Space Station Project Manager.

6.4 LEWIS RESEARCH CENTER (LeRC)

The Lewis Research Center (LeRC) will provide support to Level B relative to the definition, design, and analysis of the power system for the Space Station and platforms of the Space Station Program (SSP). This support also includes systems Engineering and Integration (SE&I) for the power system.

The LeRC Work Package addresses all aspects of the definition, design, and analysis of the power system for the Space Station and platforms of the SSP. The complete power system is included with the production of electrical energy during contingency and/or emergency conditions using energy storage equipment or other means as appropriate.

The power system consists of power generation, energy storage, power management, and conditioning subsystems. This work package also includes the development of systems data related to the above program elements as required to support the NASA in-house SE&I effort, including overall power analysis and development of overall power system architecture and standards.

FIGURE 6-5
JOHN F. KENNEDY SPACE CENTER ORGANIZATION

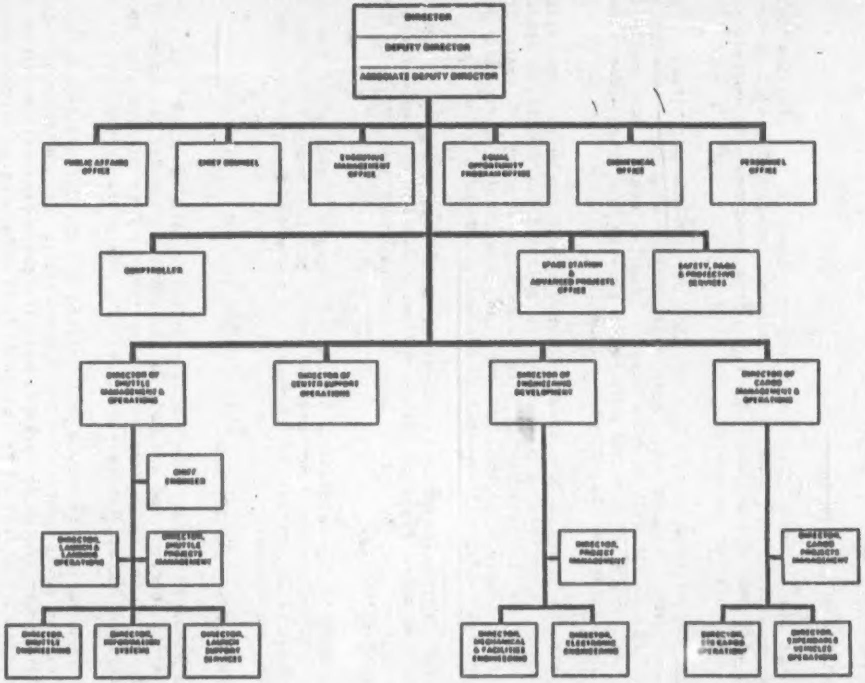
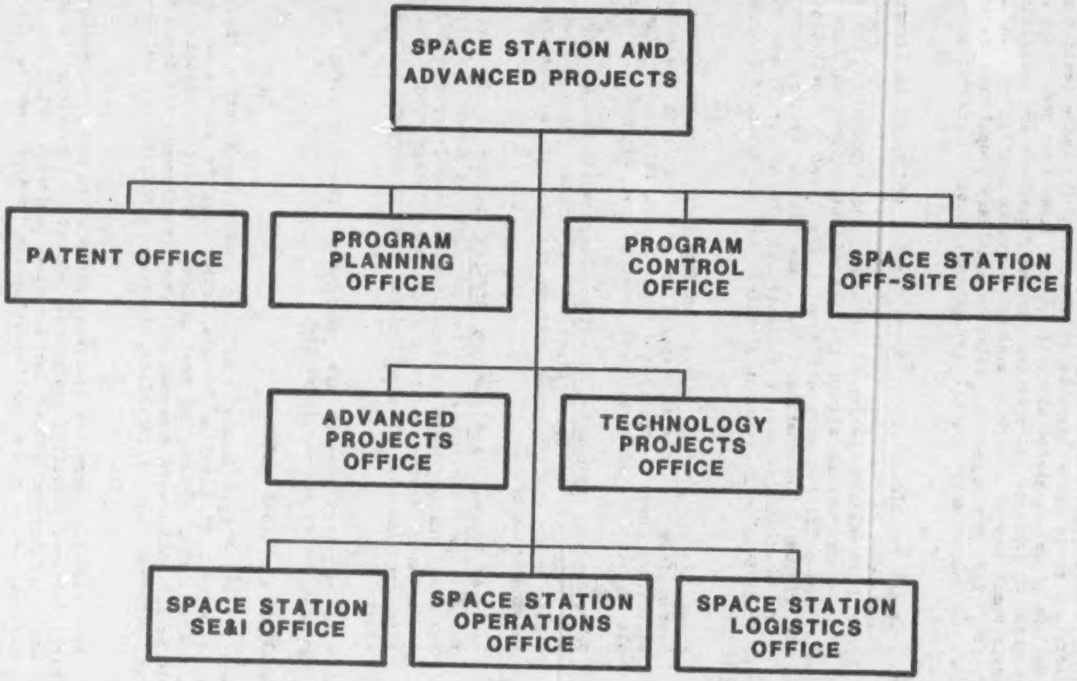

DIRECTOR
DEPUTY DIRECTOR
ASSOCIATE DEPUTY DIRECTOR
PUBLIC AFFAIRS OFFICE
CHIEF COUNSEL
EXECUTIVE MANAGEMENT OFFICE
EQUAL OPPORTUNITY PROGRAM OFFICE
HISTORICAL OFFICE
PERSONNEL OFFICE
COMPTROLLER
SPACE STATION & ADVANCED PROJECTS OFFICE
SAFETY, RQ&A & PROTECTIVE SERVICES
DIRECTOR OF SHUTTLE MANAGEMENT & OPERATIONS
DIRECTOR OF CENTER SUPPORT OPERATIONS
DIRECTOR OF ENGINEERING DEVELOPMENT
DIRECTOR OF CARGO MANAGEMENT & OPERATIONS
CHIEF ENGINEER
DIRECTOR, LAUNCH & LANDING OPERATIONS
DIRECTOR, SHUTTLE PROJECTS MANAGEMENT
DIRECTOR, SHUTTLE ENGINEERING
DIRECTOR, INFORMATION SYSTEMS
DIRECTOR, LAUNCH SUPPORT SERVICES
DIRECTOR, PROJECT MANAGEMENT
DIRECTOR, MECHANICAL & FACILITIES ENGINEERING
DIRECTOR, ELECTRONIC ENGINEERING
DIRECTOR, CARGO PROJECTS MANAGEMENT
DIRECTOR, STS CARGO OPERATIONS
DIRECTOR, EXPENDABLE VEHICLES OPERATIONS

FIGURE 6-6
JOHN F. KENNEDY SPACE CENTER
SPACE STATION & ADVANCED PROJECTS OFFICE


SPACE STATION AND ADVANCED PROJECTS
PATENT OFFICE
PROGRAM PLANNING OFFICE
PROGRAM CONTROL OFFICE
SPACE STATION OFF-SITE OFFICE
ADVANCED PROJECTS OFFICE
TECHNOLOGY PROJECTS OFFICE
SPACE STATION SE&I OFFICE
SPACE STATION OPERATIONS OFFICE
SPACE STATION LOGISTICS OFFICE

Technology development for advanced power systems encompasses power generation, energy storage, and power management and distribution. The complexity of an electrical power system capable of supporting the Space Station necessitates the use of an integrated electric power systems test bed. Such a test bed is required to evaluate concepts and component hardware and materials in a system environment and as a working part of a system similar to that of the Space Station. LeRC has supporting roles in auxiliary propulsion, materials, structures and mechanisms, thermal management, customer integration, and communications.

The organizational relationships for Space Station are shown in Figures 6-7 and 6-8. The Director of the Space Station Systems Directorate is responsible for all Space Station work performed at Lewis and reports to the Center Director. The organizations within the Space Station Systems Directorate manage Lewis' Space Station work and support the Level B requirements for technical and financial information. The Space Station Systems Directorate consists of three division-level organizations: The Power System Project Office, the Power Systems Engineering Division, and the Advanced Programs and Planning Office.

- Power Systems Project Office: Manages all aspects of the Power System for the Initial Capability Space Station including the Definition Phase contracts and Power System interfaces. The office also directs the advanced development program for power.

- Power Systems Engineering Division: Responsible for all engineering and design of the Space Station Power System, plus evaluation of growth space station power systems and analysis of auxiliary propulsion concepts.

- Advanced Programs and Planning Office: Serves as the focal point for all Space Station activities not directed toward development of the Space Station power systems, including auxiliary propulsion, the evolutionary space station and customer integration. The office also provides project planning and control support to the Directorate.

Technical and budgetary support are provided to the Directorate by other Center organizations by the matrix method.

6.5 GODDARD SPACE FLIGHT CENTER

The Goddard Space Flight Center (GSFC) is conducting specific engineering studies in support of Level B Systems Engineering in such areas as data systems and automated engineering tool designs. Goddard's customer utilization role is directed toward ensuring that user requirements for Space Station platforms, attached payload interface, laboratory outfitting, and servicing are met.

The GSFC work package covers the analyses, definition, and development of the platform(s), customer servicing equipment, laboratory for scientific and life science uses, and accommodations for attached payloads. Platform elements will be derivatives of Space Station subsystems and/or modules where cost effective.

FIGURE 6-7
LEWIS RESEARCH CENTER

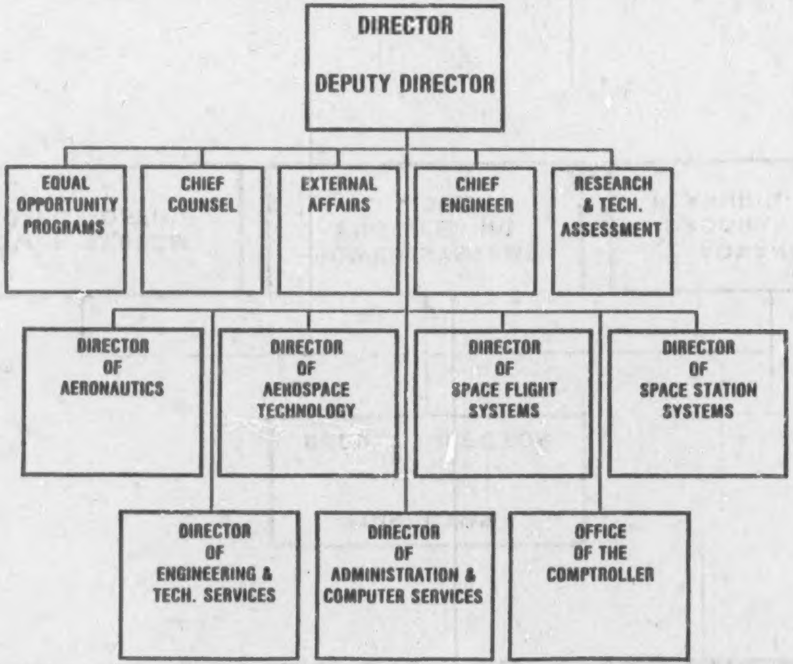
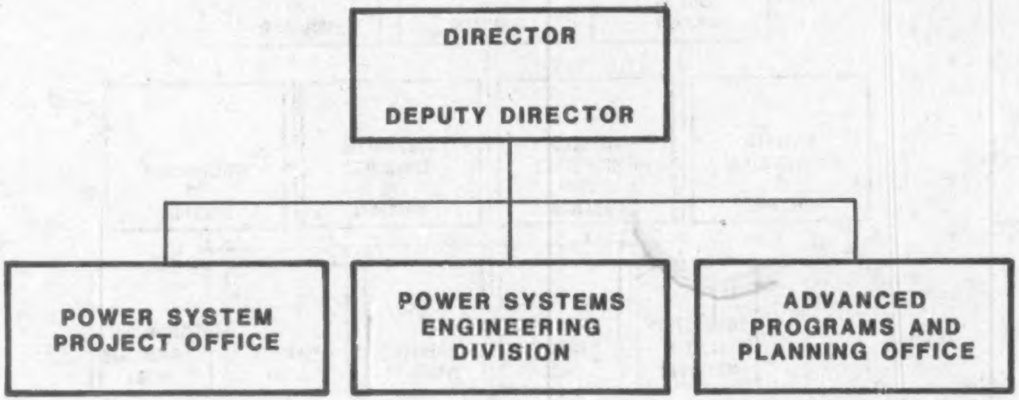

DIRECTOR
DEPUTY DIRECTOR
EQUAL OPPORTUNITY PROGRAMS
CHIEF COUNSEL
EXTERNAL AFFAIRS
CHIEF ENGINEER
RESEARCH & TECH. ASSESSMENT
DIRECTOR OF AERONAUTICS
DIRECTOR OF AEROSPACE TECHNOLOGY
DIRECTOR OF SPACE FLIGHT SYSTEMS
DIRECTOR OF SPACE STATION SYSTEMS
DIRECTOR OF ENGINEERING & TECH. SERVICES
DIRECTOR OF ADMINISTRATION & COMPUTER SERVICES
OFFICE OF THE COMPTROLLER

FIGURE 6-8
LEWIS RESEARCH CENTER SPACE STATION SYSTEMS DIRECTORATE


DIRECTOR
DEPUTY DIRECTOR
POWER SYSTEM PROJECT OFFICE
POWER SYSTEMS ENGINEERING DIVISION
ADVANCED PROGRAMS AND PLANNING OFFICE

DSG-1406

This work package also includes the development of systems data related to the Space Station Program Elements to support the NASA in-house customer integration and systems engineering and integration effort. It will encompass significant participation in the analysis of requirements for the customer space and ground components of the Space Station Information System.

The areas of advanced technology for which Goddard has been given particular responsibility deal with those having the most critical influence upon Space Station Program interfaces with customers and user payloads. Breadboards of advanced technology elements will be tested and evaluated in a laboratory data system environment at Goddard. Hardware and software products from this focused technology project also will be tested in an integrated manner using the data system test bed being developed at the JSC under the Space Station Program. Testing will be conducted by physical transportation of components or by setting up remote communication links. In the areas of data systems and thermal systems technology there is close collaboration between the corresponding groups at Goddard and the Johnson Space Center.

Goddard created a centralized Space Station Organization within the Office of the Director of Flight Projects. The Goddard Space Flight Center organization is shown in Figure 6-9. The manager of the Goddard Space Flight Center Space Station Organization is the Deputy of Flight Projects for Space Station and administratively reports directly to the Director of Flight Projects. The Goddard Space Flight Center Space Station Organization is shown in Figure 6-10.

The Deputy Director of Flight Projects for Space Station is responsible for overall management and direction of studies, design, and development of Space Station activities assigned to the Goddard Space Flight Center. The Deputy Director of Flight Projects for Space Station has direct access to the other directorates for technical support for discharging the Space Station organizational responsibilities. He represents the GSFC for all Space Station activities and, as such, reports functionally to the Goddard Center Director.

The Mission Operations and Data Systems Directorate and the Engineering Directorate both have implementation responsibility for advanced development activities at the Goddard Space Flight Center. This work is reported to the Space Station Organization directly through the appropriate technical project managers. The Space and Earth Sciences Directorate plays a key role in ensuring scientific user input to Goddard's Space Station activities. The focal point for this activity in the sciences directorate is the Associate Director of Space and Earth Science for Space Station. This individual advises the Deputy Director for Flight Projects for Space Station. To support the Associate Director for Science, a user working group will be established representing NASA, universities, and private sector organizations. This group will validate the scientific requirements of proposed science and applications missions to be flown on the Space Station as well as provide advice and review of design activity affecting GSFC's charter.

FIGURE 6-9

GODDARD SPACE FLIGHT CENTER

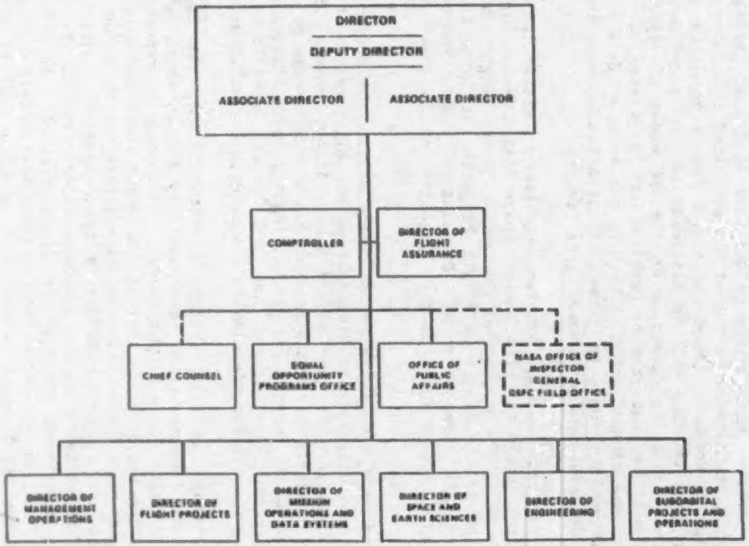
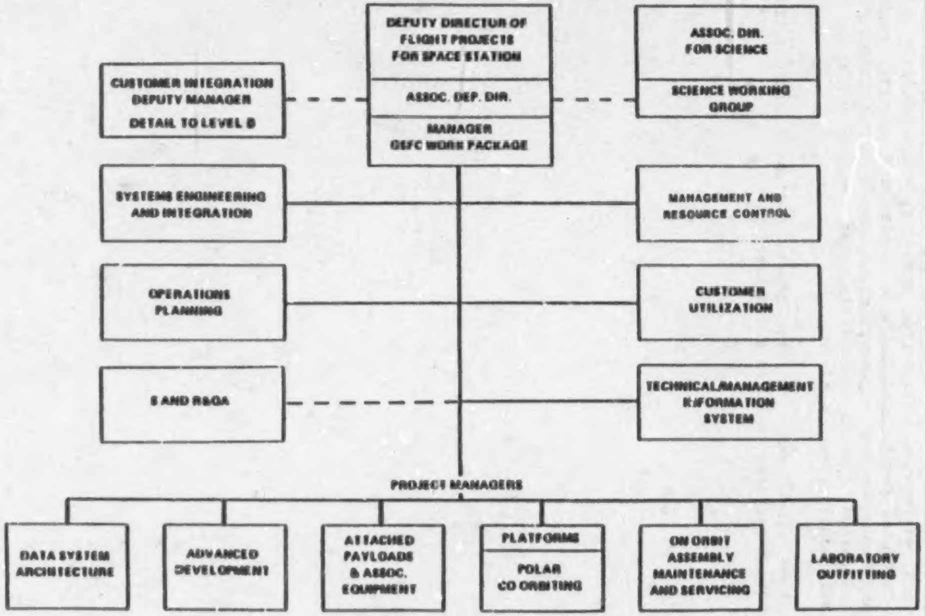

DIRECTOR
DEPUTY DIRECTOR
ASSOCIATE DIRECTOR
ASSOCIATE DIRECTOR
COMPTROLLER
DIRECTOR OF FLIGHT ASSURANCE
CHIEF COUNSEL
EQUAL OPPORTUNITY PROGRAMS OFFICE
OFFICE OF PUBLIC AFFAIRS
NASA OFFICE OF INSPECTOR GENERAL GSFC FIELD OFFICE
DIRECTOR OF MANAGEMENT OPERATIONS
DIRECTOR OF FLIGHT PROJECTS
DIRECTOR OF MISSION OPERATIONS AND DATA SYSTEMS
DIRECTOR OF SPACE AND EARTH SCIENCES
DIRECTOR OF ENGINEERING
DIRECTOR OF SUBORBITAL PROJECTS AND OPERATIONS

FIGURE 6-10
GODDARD SPACE FLIGHT CENTER SPACE STATION ORGANIZATION


DEPUTY DIRECTOR OF FLIGHT PROJECTS FOR SPACE STATION
ASSOC. DEP. DIR.
MANAGER GSFC WORK PACKAGE
CUSTOMER INTEGRATION DEPUTY MANAGER
DETAIL TO LEVEL B
ASSOC. DIR. FOR SCIENCE
SCIENCE WORKING GROUP
SYSTEMS ENGINEERING AND INTEGRATION
MANAGEMENT AND RESOURCE CONTROL
OPERATIONS PLANNING
CUSTOMER UTILIZATION
S AND R&QA
TECHNICAL/MANAGEMENT INFORMATION SYSTEM
PROJECT MANAGERS
DATA SYSTEM ARCHITECTURE
ADVANCED DEVELOPMENT
ATTACHED PAYLOADS & ASSOC. EQUIPMENT
PLATFORMS
POLAR CO ORBITING
ON ORBIT ASSEMBLY MAINTENANCE AND SERVICING
LABORATORY OUTFITTING

6.6 AMES RESEARCH CENTER, LANGLEY RESEARCH CENTER, NATIONAL SPACE TECHNOLOGY LABORATORY, AND JET PROPULSION LABORATORY

These Level C centers will participate in many aspects of the Program depending on their areas of expertise. They will be responsible for conducting supporting tasks in program areas of mission and systems requirements definition, systems engineering and integration analysis, extravehicular activity (EVA) systems, advanced development projects design and testing, technology development, autonomous systems engineering and development, customer accommodation and integration, operations analysis, cost modeling and analysis, and planning for evolutionary growth options.

These centers have established, in some cases, dedicated organizations to provide management interfaces to Level B and Level C.

7.0 SPACE STATION PROGRAM ACQUISITION STRATEGY

7.1 INTRODUCTION

The National Aeronautics and Space Administration's (NASA's) senior management has examined the full spectrum of procurement techniques and has adopted a Space Station Program acquisition strategy that applies the most appropriate techniques to each phase of the Program. Thus, in developing the Program requirements and conceptual design in Phase A, NASA selected a competitive, negotiated procurement calling for firm fixed-price proposals.

In the Space Station Advanced Development Program, NASA's procurement strategy maximizes the involvement of U.S. industry through competitive procedures initiated by the individual NASA field centers. Directed procurements would be used only to continue or expand a competitively selected activity and where it would be in the best interests of the government.

Between October 1983 and February 1984, NASA considered various procurement strategies for the definition phase (Phase B). The procurement strategy that arose from this effort is a distributed "work package" acquisition approach. A single Request for Proposal (RFP) defining four work packages was released, and NASA will award one or more parallel, fixed-price, 18-month contracts for each work package. Each Level C Center will be responsible for the procurement activity associated with the definition phase of its respective work package. Each major procurement action will have considerable Level B management involvement, plus the normal Level A review and approval requirements. As NASA moves through the definition phase, it will crystalize detailed procurement planning for the design and development phase (Phase C/D).

More detailed discussion of the procurement strategy follows.

7.2 PHASE A - SPACE STATION NEEDS, ATTRIBUTES, AND ARCHITECTURAL OPTIONS STUDIES

In August 1982 NASA awarded eight Space Station Needs, Attributes and Architectural Options study contracts. The contractors collected and analyzed the science, applications, commercial, U.S. national security and space operations missions that will be materially benefited by the availability of the Space Station Program attributes and capabilities necessary to satisfy the mission requirements. These studies also recommended mission implementation approaches and architectural options and time-phasing of the implementation concepts.

The Space Station Mission Model and initial architectures were developed as a result of these studies. The Space Station Mission Requirements Workshop held at the Langley Research Center synthesized the results of these studies and concurrent in-house NASA studies into a Mission Requirements Document that is being used as a baseline input to the definition phase.

7.3 ADVANCED DEVELOPMENT PROCUREMENT STRATEGY

The Space Station Advanced Development Program has four key activity elements: focused technology, prototype development, test beds, and flight experiments. Acquisitions in support of these activities began in October 1984 and will continue throughout Space Station Program definition. The Advanced Development Program encompasses discrete tasks within the nine technical disciplines (Attitude Control and Stabilization, Data Management, Auxiliary Propulsion, Environmental Control and Life Support, Structures and Mechanisms, Thermal Management, Electric Power, Human Productivity, and Communications and Tracking). These tasks are implemented by the seven NASA Field Centers as well as the Jet Propulsion Laboratory and the National Space Technology Laboratory. The nature of the individual tasks range from the development of components and subsystems incorporating new technologies to the operational support of component and system testing (e.g., test beds), to the analytical or physical integration and post flight assessment of Shuttle flight experiments. The procurement strategy for the Advanced Development Program is to maximize the involvement of a wide spectrum of U.S. industry through the use of competitive procurements initiated by each of the individual Centers. Directed procurements will be used on occasion where it is necessary to continue or expand a competitively selected activity and where it is deemed to be in the best interest of the government. Prospective definition phase contractors will be encouraged to utilize Space Transportation System flight opportunities, NASA test beds, and other NASA development facilities in conjunction with their own advanced development resources to demonstrate to NASA the technologies being pursued. Specific acquisition strategies for this group are currently being developed. Both industry and government sponsored research and technology activities will be closely coordinated and focused by the Program and Project SE&I organizations using the results of the definition phase studies. These activities will ultimately converge into test bed projects where the new technologies will be integrated and evaluated in a system environment.

7.4 DEFINITION PHASE PROCUREMENT OPTIONS AND RATIONALE

7.4.1 Background

The Procurement Development Group (PDG) was formed by the Space Station Task Force in October 1983 to lay the groundwork for initiating the definition-phase procurement activities. The PDG was composed of engineering, scientific, management, and procurement personnel from NASA Headquarters, Goddard Space Flight Center, Kennedy Space Center, Lewis Research Center, Marshall Space Flight Center, and Johnson Space Center as well as representatives from the Concept Development Group (CDG) and the Mission Requirements Working Group (MRWG). The PDG focused the various outputs of the CDG into the specific documentation required for a procurement activity. From October 1983 to February 1984, the PDG developed procurement strategy options and documentation subsequently used by the Space Station Program in the development of the RFP.

During the spring and summer of 1984, a series of rewrites of the RFP was drafted by the organization that had been formed at JSC in April 1984 for this and other purposes. On August 6, 1984, the final draft of the RFP produced by this team was turned over to the Source Evaluation Board (SEB) for review and additional modification, as appropriate. On August 20, 1984, the SEB released its approved version of the RFP for comment to industry and to the scientific and international communities. Those comments considered appropriate were incorporated into the final RFP in early September. After review by the NASA Administrator, the RFP was released for bid on September 15, 1984.

7.4.2 Acquisition Approach

The following are salient characteristics of the selected acquisition approach:

(a) Proposals are being solicited, on a work package basis, for the definition and preliminary design of the initial operational capability of the Space Station Program, giving appropriate consideration for growth.

(b) Four work packages have been defined. NASA will perform systems engineering and integration (SE&I) with in-house resources.

(c) A single Request for Proposal has been released. Each work package has been separately defined and associated evaluation criteria specified. Offerors may propose on any one or combination of work packages, although it is NASA's intent that a single contractor not design and develop all Space Station Program elements.

(d) NASA intends to award one or more parallel, fixed-price, 18-month contracts for each work package. In order to scope the desired level of effort, NASA has provided a tentative budget allotment for each work package.

(e) NASA has retained the prerogative to make changes and shifts in work package responsibilities.

(f) NASA will synthesize in-house and contractor data into a single preliminary design. NASA intends to acquire all data that is specified to be furnished or subject to be furnished under contract to NASA with unlimited rights.

(g) NASA has reserved the right to determine, at some future time, whether the competition for final design and development will be limited to the Space Station definition and preliminary design contractors or whether competition will be open to all potential offerors.

(h) Source selection will be centralized in one Source Evaluation Board (SEB) at the Level B center. The SEB will be staffed by representatives from the Level C (work package) centers, Kennedy Space Center, and NASA Headquarters. Initial proposal evaluation will be accomplished at the Level C (work package) centers. An integration committee will assess all proposals during initial evaluation to ensure consistency and also to review systems engineering and integration plans. The Administrator of NASA will be the Source Selection Official.

(i) Contract negotiations, award of contract, and contract administration, and project management of the individual work packages will occur at the Level C (work package) centers.

7.4.3 Acquisition Advantages

For the most part, this acquisition approach is similar to NASA's traditional, phased acquisition approach. Two primary differences are the early work package definition and NASA's assumption of SE&I responsibilities. The selected acquisition approach was chosen for its compatibility with the program management and technical considerations previously discussed. Additionally, the following significant acquisition policy considerations support this approach.

(a) The benefits of early work package definition are that it:

(1) Encourages early contractor teaming. This increases private sector participation and the base of industrial capabilities, including capital investment into aerospace research, development, and facilities and peripheral areas (e.g., commercialization), and broadens the scope of the socio-economic benefits inherent in government programs (e.g., subcontracting opportunities).

(2) Facilitates greater NASA visibility and closer scrutiny of contractor performance. Smaller work elements provide greater transparency of work progress and facilitate early identification of critical technical, management, and cost risks.

(3) Enhances the climate (quantity and quality) of competition, not only during the Definition and Preliminary Design Phase but in the subsequent Design and Development Phase.

(4) Provides flexibility to accommodate, early during definition, as-yet undefined international, private sector commercial, and other participation.

(b) The benefits of NASA performing SE&I are that it:

(1) Avoids a long-term contractual commitment with one "systems" contractor.

(2) Optimizes utilization of NASA and contractor resources while vitalizing NASA's technical skills and capabilities.

(3) Minimizes duplicative and costly design and development costs and more fully integrates NASA-wide technology and research and development expertise into common hardware development through NASA ground and flight test beds.

7.5 SPACE STATION FINAL DESIGN AND DEVELOPMENT, PHASE C/D

As NASA progresses through the Definition and Preliminary Design Phase, detailed procurement planning for development will begin. Each Level C Center will be responsible for the procurement activity associated with their assigned work package. All major procurement actions will be coordinated and reviewed by Level B and approved by Level A.

Factors to be considered in the detailed procurement planning process for the Design and Development Phase include the following: (1) international participation, (2) work package content, (3) program requirements and content, (4) budget constraints, and (5) program schedules.

8.0 FACILITIES

The National Aeronautics and Space Administration (NASA) has reviewed and tested a wide range of options with regard to facilities management over the past 26 years. Its current facility management procedures involve significant interaction among the Headquarters staffing program offices and centers. Some new Space Station Program facility projects have been submitted for consideration, and management reviews and evaluations for the Space Station are included in the ongoing process at the Agency.

Facility projects are an institutional management responsibility that are essentially accomplished under the provisions of the National Aeronautics and Space Act of 1958, as amended, and annual authorization and appropriation acts. In concert with the Program Offices, the Office of Management's Facilities Engineering Division at NASA Headquarters acts as the Agency's focal point for all Construction of Facilities (CoF) activities. Specific procedures from requirements concepts through implementation and beneficial occupancy of facilities projects are outlined in NASA's Facility Project Implementation Handbook - NASA Handbook (NHB) 8820.2.

The Space Station Program Office interacts with this process by querying the NASA Centers as to pending facility requirements through the Space Station Center representatives (Level C). After initial submittals are made, a Level B Facilities Review Board, consisting of Space Station Levels A, B, and C representatives, reviews and assesses the proposed construction projects for Space Station applicability, timeliness of need, and scope. The Review Board then prioritizes the projects in terms of the Space Station support requirements. These results are presented to the Level B Program Manager and a CoF recommendation is developed for near-term and long-range facility requirements. These recommendations in turn are presented to the Associate Administrator (AA) for Space Station, Level A, who coordinates with other Program Office and institutional AA's in determining a final program position development. During this iterative process, NASA Centers, other NASA program offices, and the Facilities Engineering Division of NASA Headquarters participate to insure a supportable and viable facility construction program. The Space Station AA then recommends to the NASA Administrator those projects required to support the program.

All Space Station projects are then considered and evaluated with all other NASA requirements through the established CoF Program review cycle that results in a recommendation to the Office of Management and Budget and subsequently to the Congress. During this review cycle, and through final authorization and appropriation by the Congress, the Office of the Space Station must remain the primary advocate for each Space Station construction project. After a project is authorized and appropriated, the primary responsibility for its implementation rests with the cognizant NASA center facilities office under the oversight and management of the Facilities Engineering Division at NASA Headquarters. During construction project implementation, there is a continuing program office interaction at all levels, to ensure that requirements have been properly defined and incorporated into the construction project.

APPENDIX A

LIST OF ACRONYMS

AA	Associate Administrator
AIA	Aerospace Industries Association
ARC	Ames Research Center
ASEB	Aeronautics and Space Emergency Board
ATAC	Advanced Technology Advisory Committee
CAG	Commercial Advocacy Group
CCB	Configuration Control Board
CDG	Concept Development Group
CDR	Critical Design Review
CODMAC	Committee on Data Management and Computation
CoF	Construction of Facilities
CSG	Contract Start Date
CSI	California Space Institute
DMS	Data Management System
DoD	Department of Defense
ECLSS	Environmental Control & Life Support System
ESA	European Space Agency
EVA	Extravehicular Activity
GSFC	Goddard Space Flight Center
ICD	Interface Control Documents
IRR	Interface Requirements Review
JPL	Jet Propulsion Laboratory
JSC	Lyndon B. Johnson Space Center
KSC	Kennedy Space Center
LaRC	Langley Research Center
LeRC	Lewis Research Center
MRWG	Mission Requirements Working Group
MSFC	George C. Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NAC	NASA Advisory Council
NHB	NASA Handbook
NSTL	National Space Technology Laboratory
OAST	Office of Aeronautics and Space Technology
OMV	Orbital Maneuvering Vehicle
OSF	Office of Space Flight
OSSA	Office of Space Science and Applications
OSTDS	Office of Space Tracking and Data Systems
OTV	Orbit Transfer Vehicle
OWG	Operations Working Group
PDG	Procurement Development Group
PDR	Preliminary Design Review
PIA	Program Initiation Agreement
PMO	Program Management Office
PMS	Performance Management System
PPWG	Program Planning Working Group
RFP	Request for Proposal
SDR	System Design Review
SAB	Space Applications Board
SEB	Source Evaluation Board

LIST OF ACRONYMS (Continued)

SE&I	Systems Engineering & Integration
SRR	System Requirements Review
SSB	Space Science Board
SSP	Space Station Program
SSPO	Space Station Projects Office
STS	Space Transportation System
TAM	Technical Area Manager
TFSUSS	Task Force on Scientific Uses of the Space Station
TMIS	Technical & Management Information System
WBS	Work Breakdown Structure
WP	Work Package

APPENDIX B

NASA MANAGEMENT PRINCIPLES TO ACHIEVE EXCELLENCE

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

SEP 21 1984

TO: Officials-in-Charge of Headquarters Offices
Directors, NASA Field Installations

FROM: A/Administrator

SUBJECT: NASA Management Principles to Achieve Excellence

Enclosed is a statement of management principles that I would like to be communicated to all employees. They were formulated, with your help, to explicitly state our long term management approach and commitment. I believe these principles are key to building and maintaining a work environment which encourages the pursuit of excellence by us all.

It goes without saying that good management is fundamental to quality efforts and productive work. The proper communication and reinforcement of these principles will help create a consistent set of Agency-wide management values. New employees should become familiar with the enclosed statement, and we should take steps to incorporate them into our training programs.

It would be appropriate for you to personally endorse this statement of principles in your organisational element and to encourage your subordinates to discuss them with all employees.

James M. Beggs

Enclosure

NASA'S MANAGEMENT PRINCIPLES TO ACHIEVE EXCELLENCE

We Demonstrate Belief In Our People By:

Taking on inspiring National goals, translating them to challenging objectives at each level, and acknowledging the collective responsibility of managers and team members.

Demonstrating confidence and respect for all members of the NASA Team, rather than depending upon regulating behavior through excessive rules and regulations.

Entrusting responsibility and authority to the lowest practicable operating level in order to encourage initiative and pride and to minimize bureaucracy and paperwork.

Encouraging honest, open and frequent two-way communication on all matters affecting team members and the work.

We Manage For Success By:

Hiring a high quality and integrated work force, providing them opportunity for creative and productive work, and maintaining a positive climate for personal development and career growth.

Stressing world class quality and pride in performance at every working level and recognizing each outstanding contribution.

Communicating clearly defined goals and focusing on successful performance through systematic program planning and execution.

Encouraging as much contractor competition as appropriate, and executing programs through non-adversarial team efforts.

Providing to all offices and facilities the modern equipment needed for quality and productive work.

We Operate With An Open Management Style By:

Recognizing that inherent in R&D are high-risk and high-payoff efforts, and maintaining high technical credibility and improving performance through free and open reviews of technical failures.

Encouraging those who are responsible for carrying out the work to make suggestions for improvements and participate in the planning.

Providing ample opportunity for our people to communicate with the best minds in science and technology in other organizations.

Maintaining integrity in all our dealings with the NASA Team and all outside individuals and organizations.

James M. Beggs
James M. Beggs
Administrator

September 1984